INDUSTRIAL

AND

COMMERCIAL GEOGRAPHY

THIRD EDITION

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Preface

If you had chanced to be acquainted with rural U. S. A. twenty or thirty years ago, you might have seen in any one of a thousand counties groups of "honest farmers" repairing roads. With pick and shovel, horse-drawn plow, dirt scoop and cart, the farmers were "working out their road taxes." They had a pleasant social time as they heaved some dirt to fill the ruts. In some places two horses dragged a scoopload of earth to fill the major ruts and gulleys. Building new roads followed the same technique.

Now the bulldozer rips along on its caterpillar feet, flinging dirt and stones before it like chaff before the wind. The two-horse dirt scoop of the farmer is gone from the roadside. In its place a tractor-drawn monster on huge rubber tires tucks ten tons of earth into its wide belly and waddles along to the place of deposition. The ruts are gone now—roofed over with concrete or asphalt.

Old Dobbin no longer draws the chaise along the highways except in very isolated places. He is out of place where strings of autos outspeed the fastest race horse. Also the farmer's wagon stays off the road in most localities. The dealer from town often sends a truck to the farm to get the produce.

Yet more! Dobbin has almost stopped pulling the plow. An ungainly creature of metal, seemingly half reptile and half gigantic insect, now draws the plow. Instead of plowing two acres a day, a fair output for the horse-drawn plow, a gang of discs, operated by one man, plows nearly two hundred acres in a single day (see picture on page 410).

Go around the circle of productive industry and transport, and everywhere you will find that in the recent past power-driven mechanisms have enabled frail man to be vastly more productive than before. In the loom room, the spinning room, the machine shop, the rolling mill, the blast furnace, the chemical works, the cement plant, the sawmill, on the farm, on the highway, on the sea, and in the air—everywhere it is the same. Supergigantic power has made us, of this generation, many times as productive of *things* as were our grandfathers.

Now it so happens that every important new mechanism changes the relation of man to the earth, changes the total of available resource, makes industry in new places and, perchance, unmakes it in the old centers. Thus we live in a new world, one much newer than the world Columbus discovered. Columbus found merely more of a world that all men knew. Today we inhabit a world that is *different,* very different from the one into which we were born, different even from the world of but two decades ago. It is a world made new by the Power Age, which has engulfed us so suddenly.

In this, the third edition of this book, we resurvey the industries and resources of the world as they have been changed by the Power Age. We begin our study of the world in this new age by discussing mechanical power and appraising some of the results power has produced.

In the first 733 pages, we describe the great industries, and the great economic activities, each set in a geographic mold. For example, we discuss the wheat industry of the world in one chapter. The wheat crop fits into certain groups of natural conditions that exist in all six continents. Some wheat-growing countries import wheat, others export wheat. The explanations of these differences lie in a combination of natural conditions and ratios between men and resources. This method of presenting an industry permits us to make comparisons and to bring causes and results together in their explanatory relationships. This stimulates interest and aids memory, because it is easier to remember when things are explained, rather than merely stated. The addition of maps, charts, and diagrams for each industry gives a sound knowledge of the production and trade of each country.

The last 224 pages of the text are a synthesis. This part is devoted to an analysis of world commerce, the rise of trade centers, the evolution of overland and overseas trade routes, and of the more recent airways, with concluding observations on certain trends in human affairs. This study of commercial geography permits a synthesis and a regional application of the preceding material which has dealt with the world's basic resources and industries. We believe that this method gives a better understanding of the world in which we live than would result from a brief description of the fifty or more countries in the world.

What could we do about Germany? What will be its future? Who would dare to guess? We decided that a description of prewar Germany is the best available basis for understanding what may develop there in the next decade.

A book for the decade beginning 1946 cannot use many statistical facts from the war period. The last normal year for much of the world's economic activity was 1938. We are compelled to use statistical data with regard to that fact.

Nations may rise and fall; boundaries may flicker and change; the leagues may wax and wane; civilizations may glitter or smash; nevertheless man will still be tilling for breadstuff, drawing water, digging minerals, tending flocks, weaving fabric, catching fish, hewing wood, fashioning implements, and carrying freight to and fro. The primeval and unchangeable needs of man will continue despite changes in boundary, politics, and the continuity of nations or civilizations. Furthermore, most of mankind will continue to labor in order to get the means with which to gratify some of the ever-increasing wants suggested by the diligent gadgeteers who make this age so different (for some of us) from any that has preceded it.

World War II and its writhing aftermath have made it more difficult to understand the economic life of the world community, but war and its aftermath have also made understanding more necessary. Politics and wars may change

the man-made arrangements like a kaleidoscope, but man must continue to use material resources as best he can, and the threat of chaos makes it even more important that man should know the resources of his part of the world and of the rest of it.

Those who use this book should keep abreast of current publications, because the facts of industry may change tremendously in a short period of time owing to technological change and those acts of government that are caused by ignorance concerning geography and economics—and that ignorance is great.

Throughout this book, references are made to maps, graphs, diagrams, and other illustrations. This is done by referring to the page upon which they appear. Thus, "See Fig. 796" refers to the map on page 796. This saves readers time.

The sources for many of the more patent facts and statistics are not given because the facts were derived from standard government and other publications as follows: U. S. *Statistical Abstract*, U. S. *Agricultural Statistics*, U. S. *Commerce Yearbook*, National Resources Committee *Reports*, U. S. *Minerals Yearbook*, *Statistical Yearbook of League of Nations*, publications of International Labor Office.

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Geography: A Dynamic Science

1. The Growing Importance of Geography

Japanese bombs falling upon Pearl Harbor blasted the self-complacency of the American people as did no other event in American history. Shattered at least for a time was the long-standing American indifference to the basic facts and problems of world politics, world economics, and world geography. Broken with scarcely a moment's notice were the continental shackles of American thinking. Motivated by a desire to follow the vicissitudes of a global war, the average American learned and relearned some facts of geography in a hurry. Strange names acquired new meaning—Kiska, Nagasaki, New Guinea, Palembang, Singapore, Chungking, Akyab, Basra, Casablanca, Messina, Sevastopol, Stalingrad, Narvik, Reykjavik, Iwo, Okinawa, and a myriad of other places. Bit by bit, the average American added to his meager fund of geographic information. Much of the information acquired was fragmentary and of transient importance, but World War II certainly kindled in the American mind a healthy curiosity about world affairs, and with it, a new appreciation of the importance of geographic knowledge as a tool for understanding the world in which we live.

Prior to World War II only a small segment of the American people had studied geography in any comprehending way—professional geographers, an increasing number of college and university students, and those businessmen engaged in international commerce, transportation, and finance who realized that a thorough working knowledge of geography was a prime requisite to success, a matter of profit or loss. The average American remained woefully uninterested in geography. Not since he had trudged to school as a child with a cumbersome geography book under his arm had he been exposed to the subject. That brief educational experience had been much like a dose of medicine, something to be taken and forgotten as soon as possible. Compelled to memorize the names of capitals, state boundaries, production data, and other facts that did not function, he had been swamped with details from which no ideas emerged. Seldom were the facts spread out before him in orderly fashion like a framework that helped him to examine and understand the forces at play in life. Rarely did he see the relationships between cause and effect. He was not often made to see that the facts portrayed by statistical tables, charts, and maps were mere tools for understanding regions, countries, and men.

Geography Finally Goes to College. Geography has an ancient origin, beginning with the first writings and maps of the earliest explorers, but the

This beautiful landscape in semi-arid Arizona supports less than one person per square mile.

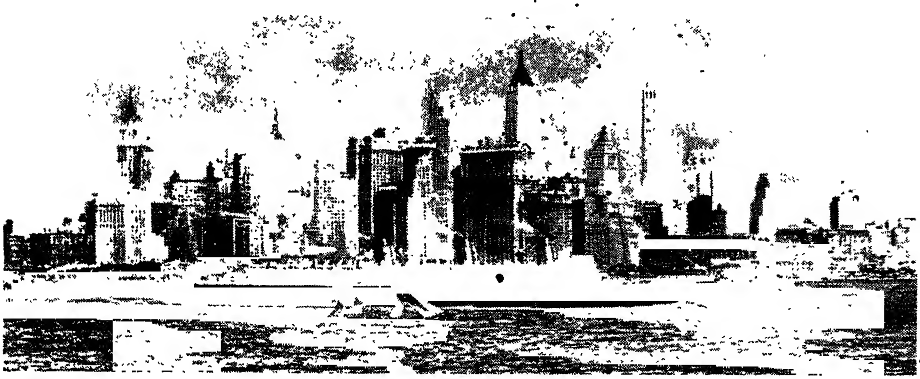
teaching of geography in American colleges and universities is very young. Largely since World War I, a few progressive college presidents and faculties have come to realize the high cultural and practical value of the subject and have instituted well-rounded curricula and full-fledged departments of geography.[1]

Economic Geography won a firm place in American schools of business administration in the second decade of this century, but the progress of geography in general education has been much slower. In the 1930's a questionnaire to five recent doctors of philosophy in history from each of ten leading American universities revealed the surprising fact that not one of the 46 who replied had had any geography in graduate school or college. *One* of the 46 had read independently a geographic book. It is to be hoped that he was not penalized for his temerity.

You can still go to some of the first 10 American universities, get your Ph.D. in Anthropology, Sociology, History, Economics, or Political Science without any formal study of geography beyond the variety that prevailed in the Seventh Grade in the days of your youth. However, World War II seems likely to produce some results even in these centers of intellectual antiquity.

There is much evidence that postwar education will show distinct increase in the belief that geography is indispensable to a proper understanding of history, government, sociology, economics, as well as business administration. Many teachers and students have come to learn that no study of the history, or the distribution and activities of mankind, is complete without a careful study of man's environment. Yet for many years in this country, as one geographer observed, it was true that "man has been so noisy about the way he has 'conquered Nature,' and Nature has been so silent in her persistent influence over

[1] For a recent account of the development of the teaching of geography, see Rafael Pico, "Geography in American Universities," *Jl. of Geog.*, vol. 40, November, 1941, pp. 291-301 (good bibliography).



This lower end of Manhattan Island has so many people working in its office buildings that if they should all rush into the streets at one time, they would be two men deep. Economic Geography explains the difference in density of population in these two landscapes.

One element of explanation lies in transport, note the *Brittania,* queen of the seas 1840, and the *Queen Mary,* queen of the seas in 1940.

man, that the geographic factor in the equation of human development has been overlooked."[2]

2. *Man and Environment: The Dynamic Elements of Geography*

Today *geography* is recognized as a science which involves a study of the *relationships* that exist between man and his environment. The concept of *relationships* makes it primarily a study of ideas, a philosophy.[3] In this book we shall direct our attention to man's major industrial and commercial activities: manufacturing, mining, forestry, agriculture, grazing, fishing, transportation, and trade. Just as economics is centered about price, geology about rocks, botany about plants, ethnology about race, and history about time—so the pivotal point of geography is place. *Where* does industrial and commercial activity occur, where does it thrive and where does it languish, *and why?* Where and why are among the most pervasive questions to be answered in this book.

Geography is a dynamic science. Man changes. Environment changes. The relationships between man and his environment must therefore change. They are now changing with ever increasing speed. Nothing about man or human society is fixed or unchanging. Human groups—their size, distribution, character, culture, customs, and economic activities—must be studied in evolution. Human wants and human abilities are constantly changing. Mankind has ever been on the move, but never so rapidly as at this time.

Dynamic man does not live in a static environment, although the rate of change in his physical environment may be very slow.[4] Prairie grass and forests

[2] Ellen Churchill Semple, *Influences of Geographic Environment,* Henry Holt & Co., New York, 1911, p. 2.

[3] The word "geography" is derived from the Greek, *gē* and *graphe,* meaning earth + description, or to write about the earth.

[4] The main elements of the physical environment of any region are its size, shape, location, land forms, bodies of water, climate, soils, minerals, and native vegetable and animal life.

disappear and with them much of the natural fauna. Mountains and hills erode. Soils develop or wash away; they lose (or occasionally gain) fertility. Lake levels advance or recede. Coastlines emerge or submerge. Rivers deposit their loads, build up or cut away. Not even climate remains the same. At times, however, nature moves with striking rapidity. Volcanoes erupt their lava and ash. The earth quivers and shakes. Typhoons and tornadoes blow. Rivers run rampant. Drought blasts wide areas. Insect pests multiply and devour. These few phenomena merely illustrate that earth, the home of man, is subject to change.

Man is not merely a resident of this earth. He is a builder and a geomorphologic agent, an earth-changer. Day by day he employs his physical strength and brain power to overcome the obstacles and to exploit the opportunities of nature. He not only adjusts himself to his environment but also adapts his environment the better to meet his needs. When man cuts down a forest, removes stones, drains swamps and makes a farm or makes a desert where there was good land, or opens a mine, or builds a town, a city, a canal, a highway, a railroad, or a dam—this, in turn, becomes a part of the environment, and man readjusts his economic life to the new situation. Thus, many cultural features have been added to the physical environment. Cultural or man-made environment is continually changing, mute but tangible evidence of human activity for good or ill, too often ill.

Since the two major elements of geography, man and his environment, are by no means static, the relationships between the two are subject to continuous change. A single illustration of these changing relationships will suffice. Because of its strategic location, the Isthmus of Panama has long been an important traffic focus. For centuries goods moved slowly across the forested isthmus on the backs of Indian porters and mules. Later a wagon road was built. With the coming of the railroad in 1855, time and the cost of transit were reduced, but the necessity of transshipping goods across the isthmus remained. With the completion of the canal in 1914, ships sailed through Panama from ocean to ocean, and the cost of transshipment was eliminated. Commerce via Panama multiplied, and the trade of the world was readjusted to the new canal. Thus, the relationships between man and his environment were definitely changed in one respect.

3. *The Variable Factors of Resource Appraisal*

In general it may be said that the type and extent of industrial and commercial activity are limited by the resources available to man. Such activity and the resources upon which it is based may vary greatly from time to time. Fundamentally, *resources* are merely environment functioning in the service of man. Hence, wherever one finds a high degree of civilization, great productivity, and a high standard of living—the explanation must always lie in the character of the people and the character of the environment in which they live.

When one reviews the long and varied story of human progress, the earth seems to hold unlimited opportunities for man. Yet it should be remembered

that there is a great difference between *available* and *potential* resources. A derelict ship, the aluminum in common clay, petroleum 30,000 feet under the ground, and most waterfalls in tropic Africa are not resources, at least not now. To be a resource, environment must actually function in the service of man. How it will be used depends upon human wants and abilities as well as upon the environment itself.

The appraisal of resources depends upon a number of variable factors: (1) individual human wants, (2) group wants or objectives, (3) technological arts, (4) institutional arts, (5) cultural environment, and, of course, (6) physical environment. Each of these factors must be considered. It will be seen that none of these factors remains constant, and, therefore, the word "resource" is a highly dynamic concept.[5]

A land may have great possibilities but nothing can be considered to be a present resource, if it is not wanted. One cannot explain a hammer or a saw without understanding its use, and so it is impossible to explain a resource without understanding its usefulness to man.

Changes in industry and in society are constantly changing the amount of resources at the disposal of any group of people. New processes make useless things usable.

It is obvious that man must satisfy from day to day his primary or creature wants, the need for food, clothing, and shelter, the indispensable things that enable him to exist. In contrast with animals, man is not content with the satisfaction of mere existence wants. To these were added long ago various and sundry secondary or cultural wants, desires for the comforts, semi-luxuries, and luxuries of life. In the aggregate, these secondary wants are constantly increasing in number and variety as our wealth increases. They are often insatiable, and are frequently changing. That "man wants but little here below" long ago proved to be an economic lie! Human *needs* are constant, but it should be emphasized that human *wants* are not the same in every place. They vary with the individual, the culture, and the environment. Patently, the Greenland Eskimo, the Chinese coolie, the South Sea islander, the Cotton Belt sharecropper, the automobile worker of Detroit, and a metropolitan magnate have vastly different individual wants. Furthermore, human wants are not the same at all times, or in all periods of history. Human wants today are quite different from those in the time of Thomas Jefferson. A virgin forest in Oregon was an obstacle and almost a dead liability to pioneers like Lewis and Clark, but to a modern lumber company and to a nearby city it is a prime asset and a great resource. Since human wants are in a constant flux, any appraisal of resources must constantly change.

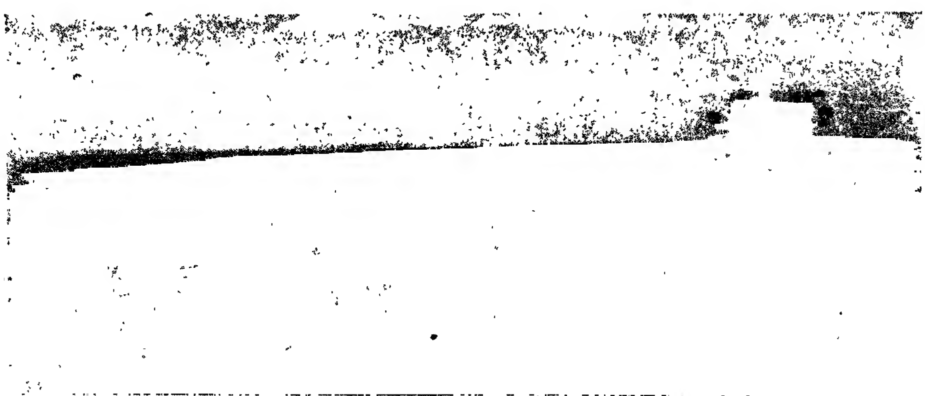
Individual wants are important, but they are merely one factor of resource appraisal. Man does not live like a hermit but rather as a member of a community or human group, for group life promotes security, efficiency, and social satisfactions. Long ago, through habit and social sanction, individual wants crystallized into group standards of liv-

[5] For a thorough analysis of the nature of resources and the major factors of resource appraisal, see Erich W. Zimmermann, *World Resources and Industries,* Harper & Brothers, Publishers, New York, 1933, pp. 3-154; also see National Resources Committee, *The Structure of the American Economy, Part I, Basic Characteristics,* June, 1939, pp. 22-32.

ing. Once these are established, groups or nations may even fight to maintain or improve their standards of living. Environment must not only satisfy individual wants, but it must permit continuous group life and promote the long-run good of the group. The village, the state, the nation lives on and the ideas and ideals of the human group become potent factors in history. The German, Italian, and Japanese people were told by their dictators that they needed more "lebensraum," or living space, and they began an orgy of military conquest. The British and later the American people saw their mode of life, their standard of living, and their very existence threatened by the Axis powers. They chose to fight.

In times of war or crisis national interests reign supreme, individual wants being subordinated to those of the group. In a nation at war certain resources achieve unusual strategic or critical importance, while those unnecessary to the war effort may be relegated into temporary limbo. Economic life becomes subject to governmental control so that the one great objective of winning the war may be achieved as speedily as possible. On the other hand, in times of peace and plenty social control seems to be less important, and private interests are given a freer hand. Like individual wants, group wants or objectives vary at different times in history and under different environmental conditions. Changes and differences in group objectives and group organization definitely affect resource appraisal. For example, environment functioning in the service of man in modern Soviet Russia is quite different from that of Russia under the Czar.

Availability. The availability of resources and their efficient use by man depend not only upon human wants but upon human abilities—the state of the arts. Environment is no resource unless it is technologically available to man. Niagara Falls was merely a scenic wonder and an obstacle to navigation prior to the invention and use of the turbine. The phosphatic iron ore at Birmingham, Alabama, was merely so much red dirt in the ground until the basic Besse-



Technology increases resources. This 100-horsepower metal beast, with two man days of driver's time, works 22 hours a day on 5 gallons of 8½-cent petroleum per hour and plows 110 acres per day. In the horse age this part of the Great Plains was poor pasture; now with care each acre may yield enough to make one man's bread, perhaps more.

mer process made possible the removal of the undesirable phosphorus, thereby making the ore available for modern iron and steel production. Nitrogen in the air was no resource until the advent of the fixation process. Many a desert remains a desert unless the wonders of irrigation are known and can be applied. Thus, many a "resource" is only a potential resource until man's growing technical skill and knowledge make it available for human use.

For hundreds, probably thousands of generations, men have used their brains, as well as their physical strength, to overcome the obstacles and exploit the advantages of nature. Year by year, century by century, man's ability to utilize matter and energy has increased. The technological arts of today are the results of this long and cumulative development of technical skill and knowledge. These arts have varied greatly in human history with time and place. In a real sense inventions and the technological arts may be regarded as devices by which man adjusts himself to his environment or by which he adapts his environment to meet his specific needs. For example, modern industrialized and urbanized Europe, lacking adequate foodstuffs and raw materials, has directed its inventive genius to the intensive exploitation of the resources at hand and to the creation of substitutes for things that were lacking or difficult to obtain. On the other hand, the United States for generations lacked an adequate labor supply and suffered from excessive space, and American inventors came to lead the world in the development of labor-saving devices and facilities of transportation and communication. Thus, inventors and industry respond to the social and economic pressure arising from specific environmental conditions.

It is interesting to note that under the

Technology destroys resources. The plow is one of the perils of the race. This almost level slope in Indiana, once good land, is eroded down to the talc—typical of millions, many millions, of American acres destroyed by unintelligent agriculture not adjusted to the resources. How long can the United States remain a great power?

impact of man many physical boundaries limiting human use tend to waver, advance, or recede. For example, the amount of land available for agriculture is fixed by the limitations of climate, topography, and soil. Yet man, the busybody with increasing skill, comes along and pushes back the frontiers of nature. He invades the land of cooler climate with short-season crops and develops drought-resistant crops for semi-arid areas. He drains wet soil, irrigates dry soil, and fertilizes poor soil. He levels rough land and creates level land on steep slopes with terraces. While there is an eventual limit to the land potentially fit for agriculture, the land actually available from year to year is a varying quantity. It increases by reclamation and decreases by erosion and other wastes.

4. Bad Human Relations Limit Resource Development in Many Lands

Man also has applied his skill and knowledge for the purpose of regulating and improving human relations. The institutional arts of today are the results of this long and cumulative process. Government functioning through courts and legislatures, religion functioning through churches, education through schools, and business through corporations, labor unions, and cooperatives illustrate institutional arts operating in the service of man. Obviously, the development of the technological and institutional arts should go hand in hand, for one is often impossible without the other. They *should* go hand in hand, but instead of that they are often generations apart. And it must be so. The railroad had made a good start by 1840. In 1940 there were still many unsettled questions about railway rate structures, and any change therein shifted industry from place to place and changed social conditions. A technological change may become vastly effective in a decade. It may take a century to make the institutional adjustments. This "cultural lag" must increasingly bedevil us if we continue to invent and use new processes with our present economic system. The House of Have resists change.

Man's apparent inability to solve the problems of war and human poverty is perhaps the greatest tragedy in world history. Perhaps these are the supreme cultural lags. Yet progress in handling human relations has been achieved from time to time, and this has helped to increase the availability of resources to man. For example, stable government and political unity, interrupted only by our Civil War, unquestionably has been a major factor contributing to the phenomenal development of the natural resources of the United States. It is hoped that the establishment of good government, unity, and peace may likewise mean much to China and thirty or forty other countries in the postwar era.

Finally, it may be noted that resource appraisal depends upon environment itself. Both cultural and physical environment, as we have seen, are subject to change. The development of the technological and institutional arts, the shifts in individual and group wants, the broad growth of civilization, have enlarged and improved the cultural or man-made environment. Man builds

bridges, tunnels, aqueducts, highways, and other productive equipment in order to overcome the obstacles and to utilize the potentialities of nature. Thus, the availability of natural resources for human use is continually increased. Furthermore, physical environment is by no means static, although the rate of change may be very slow. Human life is profoundly affected by long-run changes in land forms, bodies of water, climate, soils, minerals, and native vegetation and animal life.[6] Sporadic and short-lived natural disturbances, such as floods, storms, and droughts, obviously necessitate readjustments in human use. Man truly lives in a changing world.

From the foregoing discussion, the dynamic character of resources underlying man's industrial and commercial activity should be apparent. Will environment function and how will it function in the service of man? It depends upon six major factors, each of which is variable. Hence, nobody can say with absolute certainty and accuracy from one day to the next what are the resources available to man. Resources today, as never before in human history, need to be frequently reappraised, and this book attempts an appraisal of the world's resources in their present use as the basis of the world's major industries.

[6] No serious student of history and geography should fail to read Ellen Churchill Semple, *op. cit.*, and Ellsworth Huntington, *Civilization and Climate*, Yale University Press, New Haven, 1935.

. . . 2

Inanimate Energy: Keystone of World Power

The Influence of Climate and Location upon Human Energy and Progress

Prehistoric Farmers: the Founders of Civilization. From time to time the archaeologist digs up bones and stones and other relics and records of antiquity. All evidence points to the fact that from earliest times environment has been a mighty molder of civilization. Long before the dawn of history, the protection offered by a sheltered site and the beckoning fertility of a moistened valley lured nomadic man to cease his wanderings and turn to tillage of the soil. It was no mere accident that some of the oldest civilizations of antiquity had their origin in river valleys. In such valleys as those of the Nile and Euphrates natural barriers of the desert gave reasonable protection against invaders. Here man found rich alluvial soil annually watered by the overflow of the river and refertilized by the deposition of silt. Here man made the first large-scale conquest of nature. Native vegetation gave way to man-chosen crops, and in time natural inundation was augmented by irrigation through man-built ditches. More and more cultural features were added to the natural landscape. Here in a fixed abode community life developed and, with it, less binding custom and more elaborate law governing human relationships. The repeated experiences of a sedentary life gave rise to great material and cultural progress. Hence, when tillage begins, other arts follow, and these prehistoric farmers may be regarded as the founders of civilization and the teachers of the human race.

This shift to a sedentary life was a great step in human progress. The energy of man and beast was applied to the growing of crops, which involved the large-scale use of the energies of sun, water, and soil. Nothing so changed man's way of life until the coming of the Machine Age many centuries later when man tapped the buried energy of the fossil fuels.

Limited Progress in Lands of Tropic Abundance. Throughout the long reach of human time, no environmental factor has had a more persistent influence upon human progress than climate.[1] In general, it may be said that civilization is the product of moderate climatic adversity. For races as for men it seems debilitating to be born with a silver

[1] According to Huntington, climate, racial inheritance, and cultural development are the three great factors determining the conditions of civilization, and all three must rise to a high level if a race is to reach the highest plane of civilization. Ellsworth Huntington, *Civilization and Climate*, Yale University Press, New Haven, 1915, p. 387.

spoon in the mouth. The great civilizations of all time seem to have arisen where nature made production possible only a part of the year, and thus made it necessary for man to work and save up for the time when he could not produce. Man does not naturally like to work steadily, and if nature enables him to avoid it he usually seems content to loaf rather than labor and progress. Accordingly, there have been no great civilizations in the warm, moist parts of the torrid zone, where nature does the most to make easy the support of life. Man's wants there are so easily met and the climate is so enervating that he does not get the habit of work or become ambitious. The climate is continually warm, and the rainfall is sufficiently regular over vast areas to keep vegetation always green and growing. The native of the West Indian hill country, interior Africa, the Amazon Basin, or the South Sea islands, or any other part of the humid tropics can build himself a little shelter of palm leaves to keep off the rain; the warm climate removes the need of further shelter or many clothes. A few banana plants by the hut and a little patch of sweet potatoes will live and yield for years, for there is no frost to kill the plants. Cassava, beans, peanuts and other vegetables grow easily. The forest is full of nuts and wild fruit and game; the streams are alive with fish. Wood in abundance supplies the little fuel he needs for cooking, and if he would make himself a drum or any other simple luxury, the raw materials of the forest lie at his hand in great abundance and variety. Accordingly, the native of these regions may sit and doze most of the time, as, for untold generations, his ancestors have done before him—enervated by plenty and organizing only the small and primitive village community. Indeed it would seem that the tropic native has little to do but to lie under a breadfruit or coconut tree and wait for his food supply to drop off, a literal hand-to-mouth economy with minimum effort between.

Where great accumulations have been made, as in parts of farther India and the East Indies, the record usually shows two things: (1) a group of invaders from a cooler land; (2) a despotic ruler like Cheops of the pyramids. The function of the despot in ancient civilizations has not been fully presented.

Human energy is at its lowest ebb in the steaming tropics, for continuous tropic abundance does not require or induce the saving habit. For this reason lands of perennial plenty have never been lands of power. The lands of perennial plenty therefore fall prey to the more energetic and ambitious peoples from the lands of alternating scarcity and plenty in the temperate zone. Thus nearly all of Africa and that part of Asia within the tropics have been taken as colonies by the peoples of Europe. Only in the high plateaus are to be found the blessings of a stimulating climate resembling that of the temperate zone, as the ancient civilizations of Aztec, Inca, and Ethiopian bear witness. Here in the plateaus are to be found the greatest concentrations of population and the most progressive native and colonizing peoples within the tropics today.

Limited Progress Amidst Polar Poverty. In contrast with the lands of tropic abundance and perennial plenty are the polar and subpolar regions, where the rigors of climate place a heavy premium on human skill and energy. On bleak

tundra and Arctic islands the Eskimo spends most of his time hunting and fishing and he must work long, hard, and cleverly. The Eskimo has never studied the modern military science of camouflage, but he knows how to fool the wary seal basking at the water's edge. Clad in a white bearskin, he crawls inch by inch across the ice, making a seal-like scratching noise with an implement that has claws, finally grabs a flipper, and drives his knife home. He has never heard of Archimedes' flame throwers or seen a modern airplane catapult in action, but he knows how to launch his little boat, the kayak, when the surf is rough. His companions will swing him, boat and all, like a pendulum and let fly at a given signal, thereby launching man and boat clear of the breaking waves. He sits in the boat with the end of his outer shirt, made of watertight seal gut, tied tightly around the boat's small opening, and hence no water can enter. If the boat upsets, he can right the boat and paddle safely onward.

The marauding wolf is the Eskimo's enemy, for it kills bear, caribou, and muskox. To make a trap, he sharpens a piece of whalebone, bends it back, ties it with rawhide, and adds a lump of fat which freezes. In time the wolf comes along, smells the fat, and gluttonously swallows the trap; the sharp whalebone springs open, piercing the wolf internally and killing it. Or, the Eskimo may merely smear his knife with bait, freeze the handle fast in snow or ice, and wait for the wolf to lick the blade, cut its tongue, eagerly lap up its own life blood, and erelong drop from exhaustion and bleed to death. Patently, here in the Northland nature has no place for the man who is lacking in physical and mental energy.

In order to exist, the Eskimo makes use of every available resource and no white man has ever improved upon his devices if using only his resources. He lives in a hut of stone and sod, or sometimes an ice igloo heated by the flame of a seal-oil lamp with a wick of tundra moss. When he ventures forth into the dazzling glare of Arctic ice, his eyes are protected by shatterproof goggles made out of walrus bone with narrow slits that suffice for seeing. The bones of the mighty walrus provide the frame for his little kayak or larger umiak, the frame for his dog-sled, and material for making knives and other tools. Skins of seal, caribou or bear make warm clothing. Seal, fish, walrus, and bear are main elements of his food supply. In the long days of Arctic summer he may make a trip inland to hunt caribou and muskox, to catch migratory waterfowl, to collect birds' eggs, and to pick berries that may be preserved by drying for winter use. Or, if he is of a more sedentary type, as along the west coast of southern Greenland, he may stay at home, cultivate a patch of vegetables, and catch fish for the Danish cannery.

The Eskimo's struggle with nature is a continuous performance, and his economy with its caches of meat for winter food is of a vastly different kind from that of the dozing native in the lands of tropical abundance and perennial plenty. The meager resources of polar and subpolar regions can support only a sparse population. Indeed, all the Eskimos of North America would not fill half the seats in the Yale Bowl, and the continent of Antarctica, where nature rules with an icy hand, has not a single

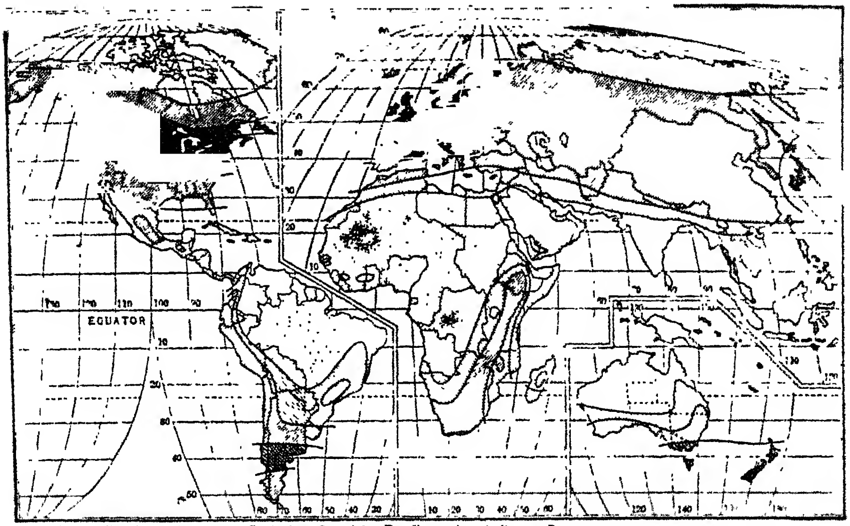
human inhabitant. In these lands of severe climatic handicaps, no great civilization has arisen, and none will.

The Stimulus of Moderate Climatic Adversity. Between the extremes of tropic abundance and polar poverty are regions where nature imposes upon man a moderate amount of climatic adversity, but also gives him a chance. In some regions the growth of crops is halted by the coming of frost and winter; in others, by the coming of the dry season. Here man must produce enough food and save enough during the season of plenty in order that he may live during the season of scarcity. Hence, the regular coming of a nonproductive season forces upon man the habits of work and thrift. He must lay aside something for the future. This habit of saving leads to the accumulation of wealth, and wealth tends to make a nation and its people powerful, whether they be ancient, medieval, or modern.

Among the first great civilizations of antiquity, as we have seen, were those that had their origin in the valleys of the Euphrates and the Nile, where a fertile soil and a seasonal moisture supply produced by an annual overflow made great crops followed by blistering drought, a kind of warm winter so far as food production was concerned. Thus Babylon, Nineveh and Thebes were rich and cultured cities at a time when all Europe lay in barbarism, and the pyramids were built before the drought-driven Joseph went down to Egypt. These valleys got their early start because their advantages as the home of man were almost unrivaled. They had a warm climate, fertile soil, and a protected location. Each year the rivers overflowed, fertilizing the soil with the muddy waters and promoting the growth of crops by irrigation. The need of a surplus of food to last through the dry season naturally produced the habit of working and saving, and resulted in a sufficient surplus of goods to support life and to allow man the leisure time to develop culture, arts, and the things we call civilization.

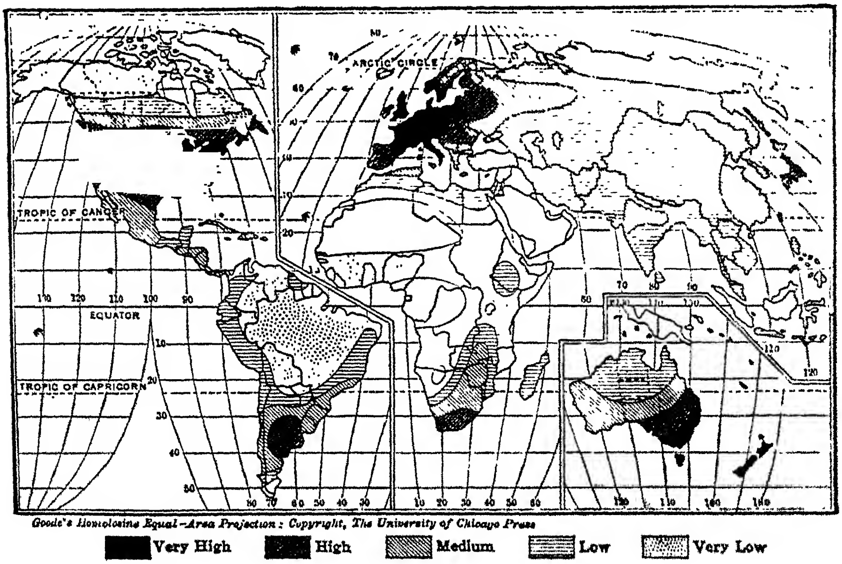
The Ideal Climate for Human Progress. It is within the lands of the temperate zone, however, where fruitful harvest is followed by the stimulus of frost that we find the best conditions for the development of energetic races. Here the coming of winter's frost and snow brings death or hibernation to the entire vegetable kingdom and drives man to the protection of heated buildings and warm clothing. Man must work and save and plan for the winter; otherwise, he faces hardship and starvation. Here, too, under conditions that are not too hot and not too cold, frequent changes in the weather spur man on to his greatest physical and mental activity. The rise of modern civilization and the development of the greatest centers of world power in the temperate lands of the North Atlantic Basin are due to a number of outstanding causes, but there can be no doubt that climate has played an enabling and a stimulating role. Conditions in the southern hemisphere give supporting evidence.

Temperature, humidity and variability are of special importance in their influence upon human health and energy. As a result of years of research, Ellsworth Huntington, Yale's great climatic enthusiast, has found that the conditions



Goode's Homolosine Equal-Area Projection: Copyright, The University of Chicago Press.

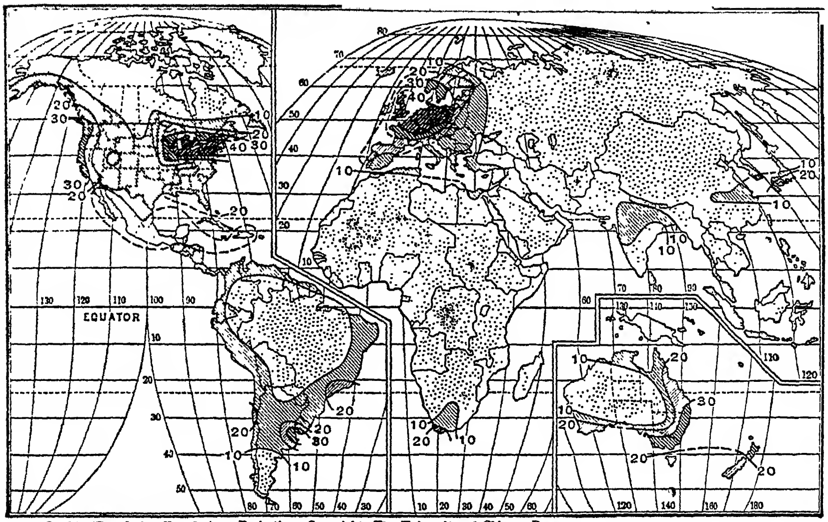
As a result of elaborate studies, Ellsworth Huntington published this map showing the distribution of climatic energy, a mighty factor in making human beings energetic.



Goode's Homolosine Equal-Area Projection: Copyright, The University of Chicago Press

B

This map is a companion piece to the Human Energy map above it. It had the advantage to be made just before World War I had torn the world with its animosities. This map was made not by Huntington's opinion, but by the opinions of leading geographers in all countries, as to how the countries should be ranked as to the height of their civilization. This map is that pre-World War I opinion of international experts. Such a map of civilization could not have been made after 1914.



Goode's Homolosine Equal-Area Projection: Copyright, The University of Chicago Press.

This map, showing the percentage of occupied men engaged in industrial pursuits, has a special significance when one compares it with the maps on the opposite page. One element not shown should not be overlooked. By a strange coincidence these areas of high civilization in Europe and North America happen to have the best and most accessible coal in the world. Suppose that coal had been in the Amazon, Congo and lower Mackenzie valleys!

of an optimum climate are as follows.[2] First, the average temperature in the coldest month should rarely fall below 38° F., which is the best temperature for mental activity, and in the warmest month it should not greatly exceed 64°, the optimum for physical activity. Second, frequent storms, or winds traversing oceans or large lakes, should keep the relative humidity quite high, except in hot weather, and should provide rainfall in all seasons of the year. Third, there should be a constant succession of cyclonic storms, or frequent breezes as along the cool coast of California, that brings about frequent and moderate changes of temperature. These conditions are most conducive to human health and energy and make the ideal climate for man.

As Huntington says, "No region on earth fully satisfies all the requirements. England and the neighboring parts of continental Europe come nearest to the ideal; but northern United States, a narrow strip close to the Pacific Coast from California to British Columbia, and finally New Zealand fall little if any behind. In [continental] Europe the chief limitation of the region within 400 miles or so of the North Sea is that changes of weather are not quite frequent and strong enough, and there are sometimes long periods of monotonous dampness. Southeastern England perhaps ranks highest in this region. Farther east, in Germany, the conditions are much like those of southern New England and New York except that changes are not quite so numerous or so extreme. The

[2] See Ellsworth Huntington, *op. cit.*, pp. 220-2[illegible], and his *Principles of Human Geography*, John Wiley & Sons, Inc., New York, 1940, pp. 343-349.

northern United States east of the Rocky Mountains has almost the right amount of storminess and humidity, but the summers are often too hot and the winters too cold, and the cold waves are too severe. The western coast of the United States, on the contrary, is almost ideal as to temperature and has a favorable degree of humidity most of the time, but does not have enough storms.

"Although the Japanese climate cannot rival those of the regions mentioned in the last paragraph, it is excellent because of its very favorable temperature except in summer, its many storms, and abundant rain. The chief difficulty in the southern part, where most of the people live, is that the summers are too warm and especially too moist.

"In the southern hemisphere, New Zealand has probably the best climate, for there are no extremes of temperature and storms are fairly abundant. The southeastern corner of Australia also has a fairly stimulating climate, as have parts of Argentina and Chile, but in these three regions cyclonic storms are not very numerous and hence there is not sufficient variability."[3]

Further support of the Huntington thesis is afforded by the achievements of the native Maori of New Zealand, the Araucanian Indians of southern Chile, and the natives of the corresponding latitude on the coast of Alaska. The Maori, magnificent specimens, are the only colored race that sits in any Parliament in the British Empire on an absolute par with the British. The courageous Araucanians maintained their independence in the face of the Spaniard until the era of repeating rifles, and the late R. C. Brooks, Alaska specialist, claimed that the Indians of the coast of southern Alaska had the most highly developed native culture in North America.

The Need of Easy Defense. The origin and development of civilization cannot be explained solely on the basis of climate, for other important factors must be taken into consideration. One such factor is man's need for easy defense. The community that has become agricultural is, with its stores of food, the natural prey to hungry nomads. One of the essences of war is transportation—speed, mobility. This is the daily practice of the nomad. From the times of the shepherd kings of Egypt to the raiding Apaches of Arizona, and doubtless back to the very dawn of agriculture, one of the commonest cycles of human history has been the conquest of the shore or valley farmer by the nomad—Hittite, Hyksos, Phrygian, early Greek, Mede, Persian, Goth, Vandal, Hun, Angle, Norseman, Arab, Mongol, Tatar, Turk, Apache.[4]

The American Indian suffered greatly from this cause as well as from the poverty that lack of beasts of burden imposed upon him. In the open country of eastern America any locality was open to easy attack; not so the cliff dwellings of New Mexico and Arizona where in an arid region the greatest Indian progress was made by people who lived in

[3] Ellsworth Huntington, *Principles of Human Geography*, John Wiley & Sons, Inc., New York, 1940, pp. 348-349.

[4] This very important piece of historical geography is really a key to much of Eurasian history. It is explained at some length in a presidential address before the Association of American Geographers. See J. Russell Smith, "Grassland and Farmland as Factors in the Cyclical Development of Eurasian History." *Annals* of Association American Geographers, September, 1943, pp. 135-161.

fastnesses easy of defense and laboriously tilled fertile patches of irrigated land in the valleys below.

For similar reasons civilizations arose in such naturally protected nooks as Athens, Sparta, Crete, and Etruria, while the great open plains of Russia and North America remained frontiers until the nineteenth century railroads brought governments strong enough to keep order and give the same protection that was afforded by a sheltered valley in ancient Greece. Today man spends billions, often futilely, to create artificial bastions of defense.

The Role of Location in Human Progress. A factor of utmost importance affecting the progress of any nation is its general location in relation to the rest of the world. Man can frequently surmount the disadvantages of a local site, but the handicaps of a poor location may militate against him for centuries. The climate of any region depends upon its location between pole and equator and its location in respect to prevailing winds, oceans and other large bodies of water, ocean currents, and mountains—and climate, as we have seen, has a powerful and persistent influence upon human progress.

The political, economic, and social consequences of location cover a large part of the pages of history. When the known world of the Occident was virtually confined to the eastern half of the Mediterranean, Athens, located midway between Asia Minor and the Italian Peninsula and opposite Egypt, enjoyed its hour of power and prosperity. Later, when civilization expanded to encompass the Mediterranean Basin, Rome reaped the advantages of central location.[5] Carthage and Rome were each too ambitious to thrive in proximity, and Carthage was obliterated. In medieval times such city states as Venice and Genoa were the centers of the commercial world with sea lanes extending to northwestern Europe and to Asia Minor, where caravan routes stretched overland to faraway Cathay. With the coming of the Commercial Revolution, the tremendous expansion of overseas trade that followed the discoveries of Columbus, da Gama, and other explorers, the center of power shifted to the Atlantic. In the bitter struggle for empire arising from the rivalries of Spain, Portugal, France, Holland, and England, it was England that emerged supreme.

The Location Factor in the Rise of Great Britain. Location meant much to the people of Great Britain as they forged the largest empire and became the greatest maritime nation in all history. As we have seen, location gives Great Britain an ideal climate for the perpetuation of an energetic race. Since Britain is located at the very doorstep of western Europe, she has long reaped the advantages of insularity without isolation. From the battle of Hastings in 1066 A.D. until the present day no hostile army has touched British soil, for the narrow English Channel has continued to serve as a priceless moat of protection.[6] British armies have fought their battles in foreign lands, while govern-

[5] See Ellen Churchill Semple, *The Geography of the Mediterranean Region*, Henry Holt & Co., New York, 1931.

[6] A few German dirigibles dropped bombs on London during World War I, and Great Britain suffered heavily from aerial attack during World War II. And, now, with the present and prospective status of air transport, one might say, in slightly figurative language—"the Channel is no more."

ment, industry, and commerce functioned in security at home. Thus, insularity and location have enabled Great Britain to participate, without becoming submerged, in the political and economic affairs of continental Europe.

A map of the world's land hemisphere reveals that Great Britain is located in the center, so Britain and nearby lands have the advantage of the shortest distance to the bulk of the world's land area. Facing the New World across the narrow North Atlantic, well situated to use the sea route to India and the Far East, and located at the edge of what came to be the most populous, productive, and progressive part of continental Europe, Great Britain was in a position to reap the maximum benefits of the Commercial Revolution. The maintenance of a powful navy, the growth of empire, the energetic development of shipping and finance, together with the advantage of a prime location for overseas trade enabled Britain to achieve commercial supremacy even before she came to lead the world into the new era of human progress known as the Machine Age.[7]

The Location of the United States. Location also has played a vital role in the evolution of American history. A nation's neighbors may be friend or foe, asset or liability. Proximity and contiguity of rival nations tends to breed friction, as the long troubled history of crowded Europe so unfortunately illustrates. In our early history this country was little more than a remote frontier of Europe. The element of distance unquestionably helped us to achieve and to maintain our national independence and to devote our attention and energy to our major problems, the conquest of a continental interior and the development of its huge and varied resources. For decades we enjoyed the security of isolation as we pushed our frontiers steadily westward. But, just as increasing improvements in transportation helped us to conquer the handicap of distance within our borders, so they brought us into closer contact with the rest of the world. By the end of the nineteenth century our last internal frontier had vanished, and the Spanish-American War made us a colonial power.[8] World War I, in turn, made us a great foreign trading and lending nation. Whatever World War II may mean to us, the American horizon is now truly global!

As we face the future, the general location of the United States in relation to the rest of the modern world seems to hold vital significance. Our country lies within the lucky middle latitudes and has within its borders a large area with a nearly ideal climate for great human energy and progress. Located between the Atlantic and Pacific, the United States among all great powers

[7] Great Britain, above all countries, was ripe for the coming of the Mechanical Revolution and the development of the factory system. Here was a supply of free and intelligent labor, for, in contrast with continental countries, serfdom had disappeared by the end of the sixteenth century. Here the old monopolistic gild system of manufacture had given way to the freedom of the domestic system. Domestic trade was free of local tariff barriers, and business was comparatively free of governmental regulation. Capital had accumulated from foreign trade and was available for investment in machines and factories. Within British borders were located in convenient proximity the indispensable deposits of coal and iron. Insularity rendered Britain free from invasion, and her general location enabled her to exploit growing markets on the continent and overseas.

[8] This war probably would never have been fought, if Cuba had not been located so close to American shores.

of today has comparatively the greatest security from invasion by land or sea. Furthermore, our location between the densely populated areas of western Europe and eastern Asia may well make this country the greatest commercial nation of the future. Indeed, the general location of the United States in the center of the civilized world of today and tomorrow is not unlike that of ancient Rome. And, finally, just as insularity, location, and growing wealth from commerce and industry enabled Great Britain to hold the balance of power in Europe for so many decades prior to World War I, so the comparative security of the United States, its prime location, and its peerless natural resources may well enable it to hold the world balance of power in the years that follow World War II. If so, this calls for an enlightened statesmanship of the highest order. Such statesmanship cannot have the right of way in our country without a great increase in geographic knowledge and understanding.

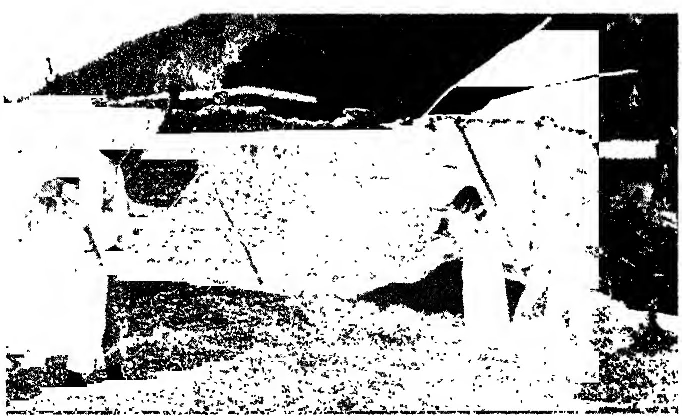
2. *The Mechanical Revolution: Divider of Mankind*

Man's Increasing Energy Supply. While climate and location have had a profound effect upon human achievement and human destiny down through the ages, it should also be recognized that human progress depends basically upon the nature and extent of man's available supply of energy, or capacity to do work. Man has ever sought and found ways to reduce the manual labor of his daily life, and each new source of energy discovered by man has helped to increase the effectiveness of his labor. Man was scarcely more than an animal before he discovered the use of fire, a chemical energy with a thousand uses. He was not civilized until he had harnessed the energy of animals and had appropriated the physical and chemical energies of sun, water, and soil through agriculture. While men of ancient civilizations made limited use of the inanimate energy provided by wind and running water, man's capacity to do work through more than 60 centuries continued to depend predominantly upon the muscles of man and beast. Indeed, it is one of the wonders of history that the ancient Aztec and Maya peoples were able to build temples and pyramids and to develop a remarkable civilization without the aid of any draft animal and that the Inca of the Andes was able to do likewise with only the aid of the little llama. Man owes much to the ox, donkey, camel, water buffalo, horse, and other domesticated animals that have made their humble and daily contribution to the work of the world. Bates claims that it was power shortage, which for many centuries caused man to harness his fellow man through the institution of slavery,[9] wherein free men were few and human beasts of burden were many. As man used the energy of the wind more effectively through improvement of the sailing vessel, his mobility was greatly increased. The introduction of gunpowder in warfare gave man a new kind of energy that helped to decide the fate of nations, chiefly by helping to destroy the feudal system. Yet, it was not until James Watt developed a practical steam engine in 1769 that man witnessed the dawn of

[9] See footnote 4.

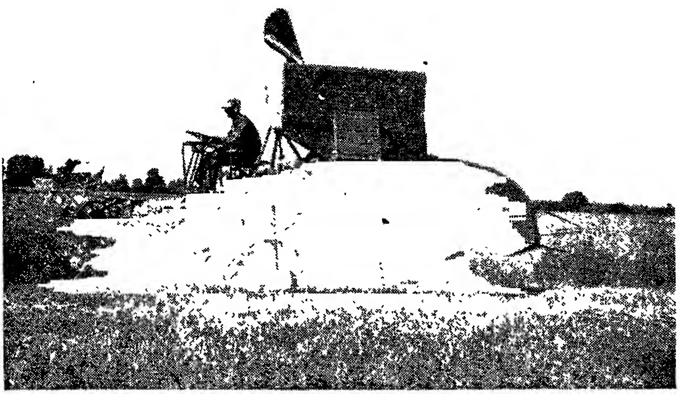
A

Cutting wheat with a cradle—a scythe with four long wooden fingers. The fingers hold grain, while the cradle swings around to the left and drops the wheat into an even row with the heads at right angles to the line of march of the worker. In 1790 this was hailed as a great invention, six times as effective as the sickle, which had been in use since the time of Pharaoh—see Egyptian pictures. According to an Iraqian archaeologist, of 1946, they have found a sickle made with cutting flints imbedded in asphalt about 8,000 years ago. The Machine Age has come upon us very suddenly.



B *© Ewing Galloway, N. Y.*

Beating the grains of wheat out of the straw with the flail. This picture is from Tibet, but the method is age old and was worldwide down to a very recent date. There was a good one in the barn on the farm where the senior author grew up.



The tractor-driven combine doing the work of a battalion of sicklers and a small company of cradlers.

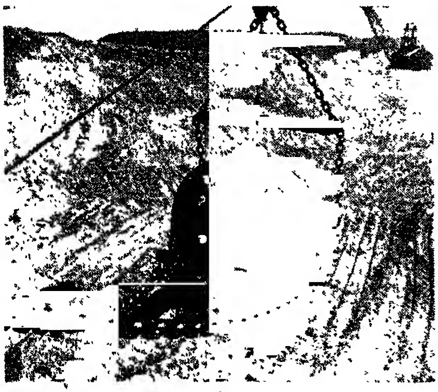
the Machine Age.[10] In this modern era man's energy supply came to be multiplied many times through the use of power-driven machinery utilizing the tremendous power of coal and water power and, later, petroleum and natural gas. Hence, the vital significance of the increasing availability of energy to man has led Fairgrieve to observe, "... there certainly are qualifications, but it may be said that on its material side history is the story of man's increasing ability to control energy."[11]

The Shift to Inanimate Energy. The Mechanical Revolution was truly a great divide in history, for it marked a transition from dominant reliance upon the energy of man and beast to an increasing dependence upon inanimate energy. Although the economic, political, and social consequences of this transition were revolutionary, the invention, perfection, and general adoption of power-driven machinery came about gradually. The first textile mills of Lancashire and Yorkshire used water power and were slow to shift from their simple water wheels to the new steam engine; indeed, as late as 1790 there were only five steam engines in use in all of England and Scotland. As one invention led to another, the power-driven machine eventually came to be increasingly used not only in manufacturing and mining but

[10] "Mechanical power is the result of the efforts of many minds, some dating back more than 2,000 years. Various mechanisms and machines were invented by man centuries ago to aid him in his labors; these, however, were insufficient to free him from drudgery until 1769, when James Watt succeeded in bringing out a practical prime mover, embodying nearly all the principles that were afterwards perfected in the modern steam engine. Engines were used for about 65 years before Watt, for pumping water from mines; while they were called steam engines, they were actually atmospheric engines in that they used steam chiefly to produce a vacuum below the piston. The necessity of finding better means for pumping water out of mines and particularly out of coal mines was mainly responsible for Watt's contribution which started the wheels of the world in motion. By demonstrating how to turn heat into mechanical work effectively, Watt helped to create an improved civilization by stimulating through his own work all forms of invention."—National Resources Committee, *Technological Trends and National Policy,* Washington, June, 1937, p. 262.

[11] James Fairgrieve, *Geography and World Power,* University of London Press, Ltd., London, 1932, pp. 3-4.

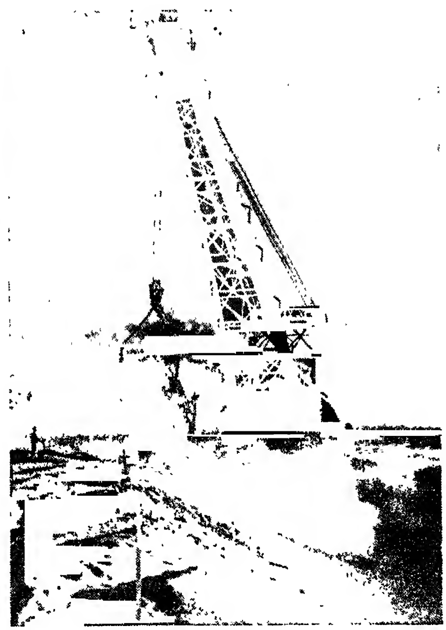
in transportation, agriculture, fishing, forestry, and other economic activities. From its English home the movement gradually spread to the United States, continental Europe, and eventually to many distant portions of the world, although there still remain vast areas in the world today that have been scarcely touched by the impact of the Machine Age. With the advancement of science, the Mechanical Revolution gained great momentum, and it has reached such proportions in this country that it seems that almost any kind of work can be done today by merely throwing a switch, turning a valve, pulling a lever, or pushing a button.



A

The scoop at the end of a dragline is big enough to hold an automobile. The operating end of a dragline is visible at the extreme upper right.

Nothing so completely changed the life of civilized man as did the coming of the Machine Age. Throughout the centuries prior to the Mechanical Revolution, man's energy supply was predominantly animate. His great occupation was agriculture. Land was his prime resource and was usually measured in two dimensions as so many units of farm or grazing land. Manufacturing remained in the handicraft stage and was decentralized in workshop and home. Commerce was confined largely to a trade in luxuries, exotics, and other commodities of high value in proportion to bulk. Those few nations that rose to pre-eminent prosperity and political power were those favored by location and climate. Then came the Revolution to those lucky peoples having easy access to coal and iron and with sufficient ability and ambition to use them, chiefly the people of northwestern Europe and northeastern United States. Here the energy of man and beast came to be eclipsed by the billions of horsepower obtained from falling water and fossil fuels. Here manufacturing was devel-



B

This is the last figure continued—the dragline has pulled the scoop, filled it with dirt, swung it through the air and dumped it—10 or 15 cubic yards—and all by the touching of a few levers and the use of a little petroleum. Don't fail to note the man at left center.

oped in factories equipped with power-driven machines, and it became man's dominant occupation with agriculture playing a subsidiary role. As the new, industrialized urban areas continued to grow, so did their exports of manufactures and their imports of low-valued, bulky foodstuffs and raw materials, a movement that was facilitated by the development of mechanized modes of transportation, notably the steamship and the railroad.

Land now acquired an important third dimension, or depth, to include mineral wealth below the ground. Economic and political power came to be concentrated in the hands of a few industrial nations, those that held easy access to coal and iron, vital sinews of the Machine Age.

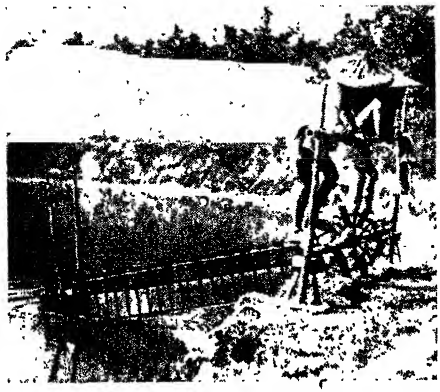
Inequalities Resulting from the Mechanical Revolution. Among the most significant consequences of the Mechanical Revolution was the inequality that it created. The obvious benefit of the power-driven machine was to increase greatly the productivity of human labor, but this advantage did not accrue equally or in a similar manner to all industries, regions, nations and peoples. Some industries lend themselves to mechanization more readily than others. Whether or not power-driven machinery will be used depends largely upon the technical difficulties to be overcome in devising a machine for a given task, the cost involved, and the ultimate profit to be derived. The more a task can be subdivided, the more amenable it is to mechanization. For example, no single machine has been devised to turn out a complete and finished shoe from leather, but machines have been invented that readily perform each of the dozens of successive steps in shoemaking. In modern automobile production the raw materials are made into approximately 15,000 standardized parts, which are combined into nine primary units and assembled into a complete car.[12] Thousands of jobs are involved, and nearly all are mechanized. Hence, division of labor, involving task specialization, greatly facilitates mechanization. Obviously those industries that can use the power-driven machine continuously and on a large scale tend to reap the greatest profit.

While exceptions are to be recognized, in general it may be said that manufacturing, transportation, and mining have been able to make far more extensive and effective use of power-driven machinery than have farming, grazing, forestry, and fishing. This inequality is to be found in the United States, which is universally regarded as the very quintessence of the Machine Age. While Americans have come to lead the world in the use of inanimate energy in virtually every branch of economic activity, the fact remains that the benefits of the power-driven machine have not accrued equally to all industries, as the following account of the difficulties of the American farmer indicates:

"The farmer is indeed a victim of circumstances. Consider the contrast between him and the big manufacturer. Eastman may hold a patent on kodaks and Dupont a patent on how to make rayon, but no farmer or group of farmers can get a monopoly on sunshine,

[12] John George Glover and William Bouck Cornell (ed.), *The Development of American Industries,* Prentice-Hall, Inc., New York, 1941, pp. 686, 688.

rainfall, soil, or how to grow spinach. The factory engineer can turn on or shut off his steam and electricity, but nobody can control solar radiation. Swift and Armour can speed up or cut down their production schedules, but a calf belonging to Farmer Jones takes as long to mature into a cow as it did in the days of Methuselah. The production of



The Oriental coolie on his tread mill—there are hundreds of thousands of him—lifts water three or four feet from a stream to the rice paddy. This might be in India, Malaya, East Indies, China.

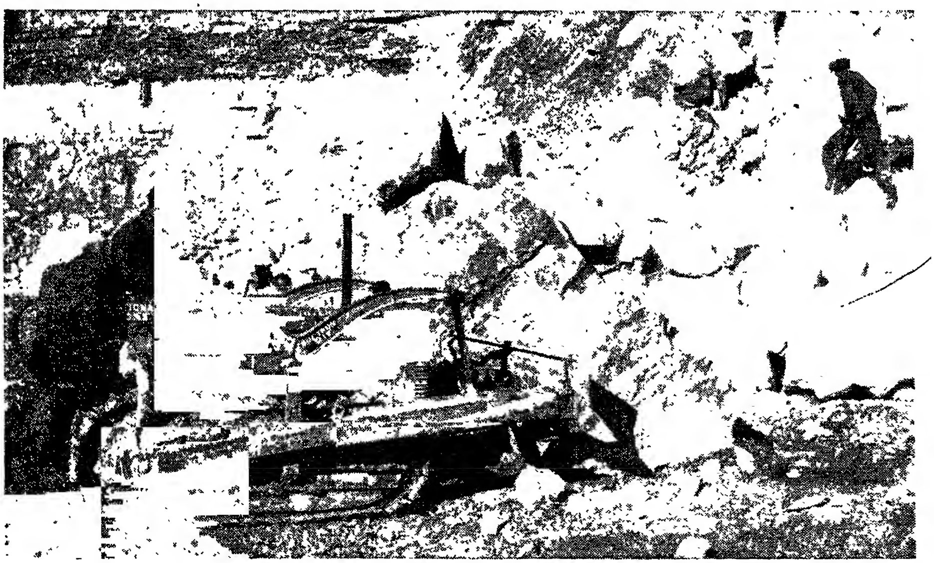
Packards can be spread evenly throughout twelve months of the year, but farm crops arrive on the market in concentrated doses, with a concomitant drop in prices. The output of Chesterfields or Lucky Strikes can be set at any figure, but pity the Secretary of Agriculture who tries to control the cotton crop without knowing what the yield will be. Goodyear's can determine the quality of its tires with micrometric precision, but nature, more often than man, sets the quality of farm produce. The sulfur-producers of America and Sicily can divide the world into exclusive sales territories, but just try to get a lasting agreement among the wheat-producers of the world, of a nation, or even of one county! Westinghouse can operate its machinery twenty-four hours a day if necessary, but the wheat combine of Farmer Jones is just so much idle capital during three hundred and fifty days of the year. The more automobiles Chrysler can run off the assembly line, the lower is the cost per car—but the more bushels of potatoes a farmer can extract from an acre of soil with increased labor, fertilizer, etc., the greater is the cost per bushel. General Electric can run its laboratories day and night to invent what it wants, but the farmer can only take or leave the farm implements that are offered for sale. Henry Ford can declare independence from the bankers and finance himself out of an accumulated surplus or by sales quotas imposed on his dealers, but Farmer Jones must go hat in hand to the storekeeper, the landlord, or the banker and pay whatever may be asked for credit. The number of big manufacturers that are outside the realm of competition is remarkable, but the farmers, operating under competition, must take whatever price they can get."[13]

Since the Mechanical Revolution did not raise all industries to a common level of productivity, it brought unequal benefit to the peoples of the various regions and nations of the world. It is not to be denied or minimized that the development of the steamship, the railroad, the automobile, refrigeration, electrification, farm machinery, the wind

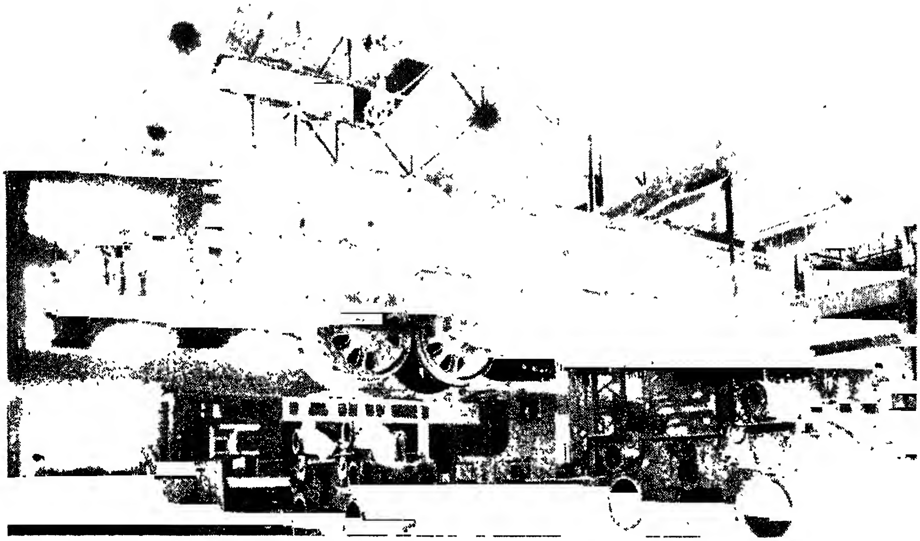
[13] J. Russell Smith and M. Ogden Phillips, *North America*, Harcourt, Brace & Co., New York, 1942, p. 425.

mill, and a thousand other wonders of the Machine Age have brought tremendous benefit to the peoples living in many agricultural and pastoral regions. And not to be discounted are the consequences from the use of donkey engines, caterpillar tractors, mechanical saws, and other machinery in modernized lumbering or the use of steam and diesel trawlers in some of the world's great fishing grounds. Yet the fact remains that, since the coming of steam, no nation living under a purely vegetable-animal economy has risen to the rank of a Great Power either politically or economically. The reason for the concentration of political power in the hands of a few great nations is obvious. Political power depends upon military might. Victory in modern warfare goes to the nation with the largest manpower equipped with the most and best machines. Hence, only those nations with a well-developed heavy-manufacturing industry capable of producing the materials needed to make battleships, artillery, tanks, planes, and other implements of war, can achieve great political power. These are the few nations that possess or have ready access to abundant energy and machine resources, especially coal and iron.

Great wealth and economic power have likewise come to be concentrated in the hands of a few great nations, especially within those urban-industrial-commercial regions that are the very core of our modern, capitalistic, mechanized, power-metal economy, notably northwestern Europe and northeastern United States. Here wealth has accumulated over the years much faster and to a far greater degree than elsewhere. This unequal distribution of wealth and economic power is due to the simple fact that the basic energy and machine resources of a power-metal economy are comparatively scarce and highly concen-



The bulldozer is moving boulders larger than barrels in a quarry, doing the work of 50 or 100 men.



Machine shop cranes pick up a locomotive, carry it from one side of the great operating floor to the other, from one end of the operating floor to the other—lower it into any desired spot.

trated, whereas the basic resources of a vegetable-animal economy are abundant and widely scattered over the face of the earth. While exceptions and differences of degree are to be recognized, in general it may be said that the products of factory and mine are relatively scarce, and their producers are few, concentrated, well organized, and frequently able to control output and price. On the other hand, the products of field, pasture, forest, and sea are comparatively abundant, and their producers are numerous, decentralized, highly competitive, and seldom able to control output or price. From any exchange of scarcities for abundances, the sellers of scarcities gain most. Hence, the people living in a power-metal economy gain far more from interregional trade than the people in a vegetable-animal economy, which cogently illustrates the old axiom of commerce that the benefits of trade are mutual but seldom equal. Furthermore, widespread foreign investments from the growing profits of commerce and manufacturing cause more and more economic power to accumulate in the great metropolitan centers of the power-metal economy.

Since nature did not distribute the vital deposits of coal and iron with an impartial hand, economic and political power has come to be centered in the great urban-industrial-commercial regions of northwestern Europe and northeastern United States. Here today are the world's great citadels of heavy manufacturing, commerce, and finance. Economically and politically, this is "the

world that matters."[14] Furthermore, it should be noted that the hegemony of coal and iron has not been seriously affected by the decentralizing influence of the electric power wire carrying energy derived from coal, petroleum, and water power or by the increasing use of copper, aluminum, and other machine resources. Hence, through the inequality that it created, the Mechanical Revolution has come to be the great divider of industries, regions, nations, and men. Today, as never before, the world stands divided into active and passive, dynamic and static, strong and weak, sovereign and subject, lender and borrower, rich and poor.[15] Keystone of world economic and political power is the inanimate energy that drives the machine, the energy that so greatly increases the productivity of human labor whether at peace or at war.

3. *Animate versus Inanimate Energy in the World of Today*

Manpower and Animal Power in Asia. The Mechanical Revolution brought great benefit to some regions, less to others, and little or almost none to remarkably large areas of the earth. In these large areas the unmechanized man can buy some cheap clock and a few gadgets. That is all. For us who live amidst the wonders of the Machine Age, it is rather difficult to realize that hundreds of millions of men have had little or no contact with the power-driven machine and that in vast areas the daily output of work continues to depend, as it has for centuries, upon human labor that is sometimes aided by the energy of draft animals. Yet such is the case in parts of rural America, in the vast polar and subpolar regions, in hundreds of thousands of square miles of tropical "back country," and in the rural, semi-medieval portions of Europe. It is especially true of southern and eastern Asia, the only large and densely populated section of the world which the Mechanical Revolution has scarcely touched. Here teeming millions continue to live in an ancient, unmechanized vegetable-animal economy, which has developed a commercial fringe along the seacoast, navigable rivers, and wherever a railroad penetrates the interior and which also has acquired a modern industrial veneer in a few favored spots. Contrasts between these

William H. Koenig

Two Malays carry a pig to market in this wicker cage. Compare with dragline and bulldozer.

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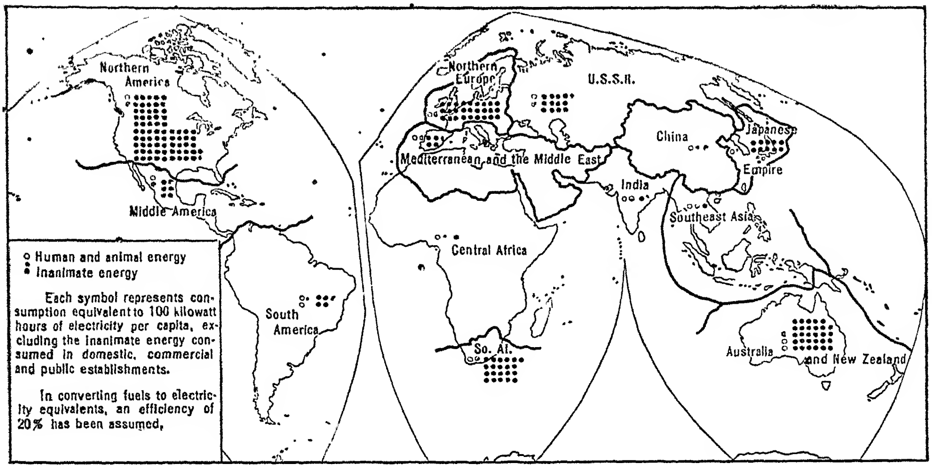
[14] For a discussion of geographic and economic factors underlying the Great Powers of today, together with excellent maps and charts, see Frank H. Simonds and Brooks Emeny, *The Great Powers in World Politics,* American Book Co., New York, 1939, pp. 43-97.

[15] For a thought-provoking analysis of the hierarchy concept, see Erich W. Zimmermann, "The Resource Hierarchy of Modern World Economy," *Weltwirtschaftliches Archiv,* vol. 33, April, 1931, pp. 431-463; for a condensed treatment of this concept, see his *World Resources and Industries,* Harper & Brothers, Publishers, New York, 1933, pp. 805-809.



The world has been divided into regions and the dots compare the amount of inanimate energy used by each person within the area. This is one of the many reasons why some countries are rich and some countries are poor. (Boggs, U. S. Dept. State.)

lands of man and beast and those of man and machine are striking.[16]

The coming of plantation agriculture to parts of southeastern Asia and the development of modern manufacturing in the Tokyo-Osaka and northern Kyushu areas of Japan, in Shanghai, Calcutta, Bombay, Jamshedpur, and other favored spots have not materially changed conditions under which the masses of southern and eastern Asia live. Here the good earth and the rain-bearing monsoon wind are man's prime resources, for three men out of four are engaged in tilling the soil with the same, or almost the same, primitive methods that their ancestors have used before them.

Nowhere in the world does one find such a heavy concentration of humanity upon arable land as in rural Japan, China, and India where 1,000 to 5,000 people per cultivated square mile are not uncommon. In many areas the land cannot support both man and draft animals. In large parts of China one sees no animals larger than a chicken or a pig, while in most of Japan there are no pigs, and a chicken is indeed a luxury. Good rice land is worth as much as $500 to $1,200 an acre. In a land of high rents and midget landholdings, averaging 2½ to 3½ acres per family, super-intensive cultivation of the land is absolutely necessary, and a huge amount of human energy is applied to each plot of ground. Where climate permits, the land is used to grow two or three crops a year. Especially in China the rural masses are almost as immobile as the soil upon which they work. Travel on foot or by jinrikisha, sedan chair, or two-wheeled cart is slow and fatiguing. Beyond the railroad or waterway, freight moves in carts, wheelbarrows, or on the backs of human porters, the

[16] For an interesting account of the resource patterns, culture areas, and economic systems to be found in various parts of the world, see Erich W. Zimmermann, *World Resources and Industries*, pp. 138-154.

strongest of whom can carry a hundred pounds about 15 or 20 miles a day. Wherever there is immobility of persons and goods, there is also an immobility of ideas, a factor that helps to perpetuate a static civilization. Most manufacturing remains in the handicraft stage, decentralized in workshop and home.[17] Where mining occurs, primitive methods predominate. All forms of work draw heavily upon human labor, and hours of toil are long. Under such conditions the pressure of population upon all available resources is terrific, and a bare subsistence standard of living prevails.

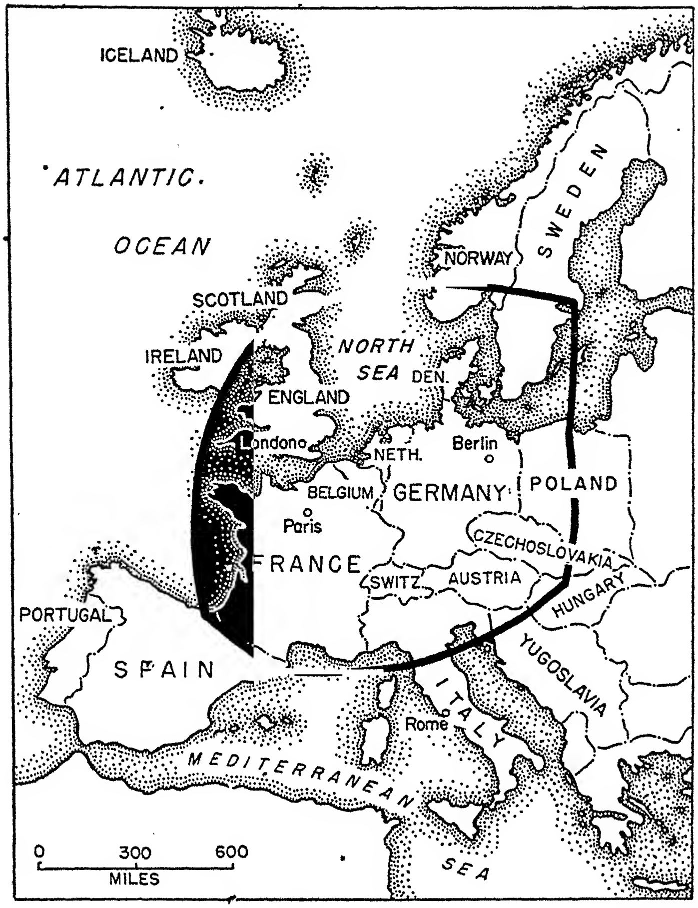
And what will happen if the population of India keeps on increasing as it has in the past 20 years?

Highly Mechanized Northwestern Europe. Whereas the teeming millions of southern and eastern Asia continue to rely dominantly upon human labor, striking contrasts are to be found within the Europe of today, where inanimate energy plays a decisive and dividing role. The little continent, excluding Soviet Russia, may be divided into two different parts.[18] Within a rough circle that may be drawn through Bergen, Stockholm, Danzig, Cracow, Budapest, Florence, Barcelona, Bilbao, and Glasgow (see Fig. 30) is to be found the highly dynamic civilization of modern, capitalistic, scientific, mechanized Europe. Here is a highly developed power-metal economy based upon the intensive use of coal, iron, and water power. This is a land of big cities, modern factories, energetic men, and millions of mechanical horsepower. Manufacturing is the dominant occupation, and to the big urban areas are brought each year vast quantities of foodstuffs and raw materials. From this area are shipped many manufactured goods to overseas markets. The internal trade of this part of Europe is large. Here people, goods, and ideas are mobile, for this land of short distances is well covered by a dense web of railways, highways, and airways, together with modern facilities of communication. Here the productivity of man has been greatly increased through the use of the power-driven machine. The population is dense, but the pressure of people upon available resources is not great, and the standard of living is relatively high. This may be called Europe A, and beyond its periphery lies Europe B, the old, semi-medieval, unindustrialized, and little mechanized Europe.

Little Mechanized Peripheral Europe. In Europe B, or peripheral Europe, one finds a little mechanized vegetable-animal economy, with agriculture playing the dominant role. Railroads and highways are few and far between, and man suffers from immobility. In this part of Europe, old customs, costumes, dialects, and primitive methods of farming have survived for centuries, especially in the more isolated areas. With little education, many men work on the good land of the small wealthy class under conditions not far removed from serfdom or else on small plots of their own. With-

[17] In Japan, which leads the Orient in industrial progress, about one-half of the persons engaged in manufacturing are employed in establishments with less than 5 workers each. In 1939 3,766,700 persons were employed by 137,422 enterprises having more than 5 workers each.—Kate L. Mitchell, *Industrialization of the Western Pacific,* Institute of Pacific Relations, New York, 1942, p. 36.

[18] See Francis Delaisi, *Les Deux Europes: Europe Industrielle et Europe Agricole,* Payot, Paris, 1929.



The area within the heavy line includes most of the important manufacturing towns of western Europe.

out coal and iron, manufacturing is unimportant. Mineral products, such as petroleum and sulfur, are largely exported to outside markets. The population is not as dense as in Europe A, but the pressure of people upon available resources is much greater. To the east of Europe B lies Soviet Russia where man, stimulated by new social objectives and with newly acquired arts, is using the power-driven machine in the remarkable economic development of a large nation. The Russians are striving to create within their vast domain another Europe A, and their achievements in World War II are very suggestive as to the outcome.

Power-driven Machinery in Rural America and Other Lands. In contrast with Europe B and southern and eastern Asia are the rural areas of temperate-zone Australia, New Zealand, Argentina, South Africa, Canada, and the United States. Here man lives in a modern, mechanized, vegetable-animal economy in lands that would be little

more than a frontier wilderness had it not been for the coming of the steamship, the railroad, and the automobile, and the resulting trade. Modern transportation gives man in these vast areas cheap access to the world markets. Often he specializes in the production of a single, low-valued and bulky commodity such as wheat, but from the sale of this commodity he can buy the many things that he needs. His market and his source of supply may be thousands of miles away, but economically they lie within his reach. While the farmer and rancher cannot use power-driven machinery as liberally, continuously, and effectively as the manufacturer, nevertheless in large areas the common can of gasoline and the gradually spreading electric power wire are doing much to reduce the drudgery of life and to increase the productivity of human labor. Here the draft animal population declines as tractors increase. Year after year the automobile, truck, tractor, water pump, electric light, telephone, radio, washing machine, refrigerator, and many other mechanical gadgets continue to invade the countryside in increasing numbers. Such a rural civilization is not static, for men, goods, and ideas continue to gain mobility. Under such conditions one finds a relatively high standard of living, which would be higher and far more widespread if our modern system of distribution could distribute what our technology can produce. In this field we are now in the midst of revolution—probably *the* great revolution. Financially, politically, and technologically, rural man continues to be subject to policies made by men in the great metropolitan centers, and his prosperity continues to rise and fall with the price of his product as determined by the fickle forces of supply, demand, and connivance in some urban market far away.

Northeastern United States: Quintessence of the Machine Age. Only within the northeastern quarter of the United States has man created a second Europe A, a gigantic urban, industrial, and commercial development that has come to surpass its parent in so many ways. Here in a land unfettered by tradition, undivided by national rivalries, relatively secure from invasion by land or sea, well located for worldwide commercial expansion, blessed with a stimulating climate, and richly endowed by nature with energy and machine resources,—man has built with exceptional ease and rapidity a civilization that stands today as the supreme manifestation of the Machine Age. Nowhere else does man make such lavish use of inanimate energy. Here man lives in a power-metal economy that contains many great centers of heavy manufacturing. In modern mills and factories large-scale production methods, power-driven machines, and cheap raw materials from a peerless hinterland combine to yield low costs per unit of output and big profits, salaries, and wages. Within this region great wealth continues to accumulate rapidly. The standard of living is the envy of the rest of the world, although in reality prosperity does not always trickle down to the lower classes, as the slums of the big cities so sadly illustrate. This region contains America's most densely developed web of railways, highways, and airways, and here the mobility of man reaches its highest peak. Of all the world's civilizations,

past or present, this is the most dynamic and the most mobile.

Distribution of Mechanical Energy Consumption. The great bulk of the world's effective consumption of me-

Hammond and Irwin

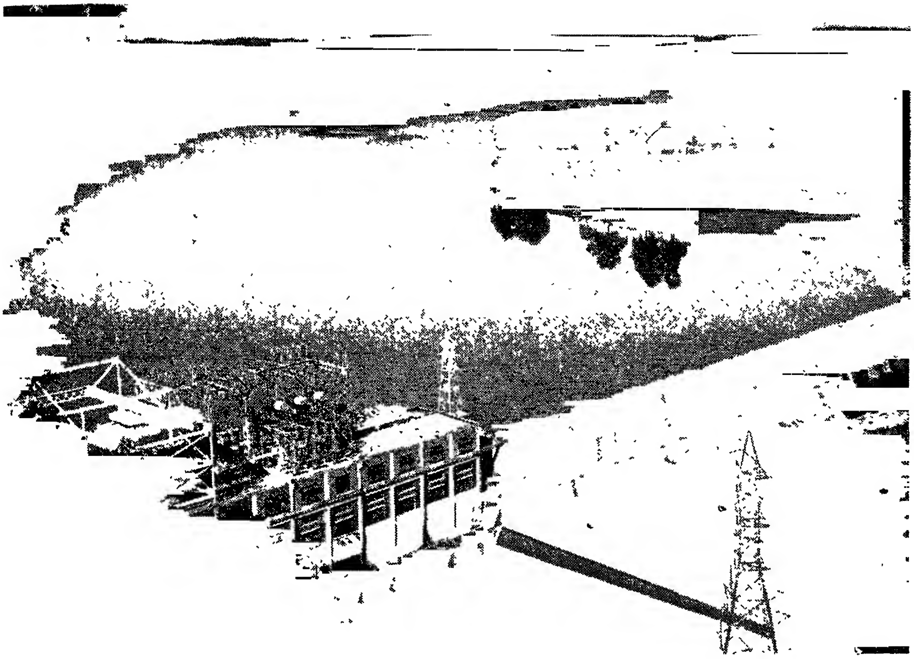
An old country waterwheel, and a rural neighborhood mill in the Ozarks of Missouri. A hundred years ago there were several thousand of them in the United States. When there happened to be water in the little creek, it was led to the top of the wheel and made to go into the so-called buckets and the weight of it ran the wheel—about one horsepower, when it ran.

chanical energy is consumed in a few countries, which are the world's industrial leaders (see Table 1). It will be noted that 54% of the world's total mechanical energy is consumed in the United States. In a single year (1937-39 average) about 746 quadrillion foot-pounds of work are accomplished in this country by power-driven machines using energy derived from coal, petroleum, natural gas, and water power. This is equivalent to the work of 20 billion inanimate slaves, or 153 slaves per capita.[19] No other country approaches the United States in the total amount of work performed by inanimate energy slaves, a fact that goes far to explain the high productivity of American labor and the final outcome of World War II. The output of man and machine is so much greater than that of man and beast that probably one-half of all the work in the world today is performed in the United States (see Table 2). Certainly no empire in the days of human slavery ever accomplished in a year the work that is now done by the American people aided by 20 billion inanimate slaves.[20]

It is scarcely necessary to point out that inanimate energy slaves are far more useful and much cheaper than human slaves could possibly be in the United States. No number of human slaves could substitute for the compact engine that drives a plane through the air at 300 miles per hour. No number of human slaves could propel a modern ocean liner at a speed of 20 or 30 knots. No ancient Hermes could hope to deliver a message with the speed now achieved through the use of the tele-

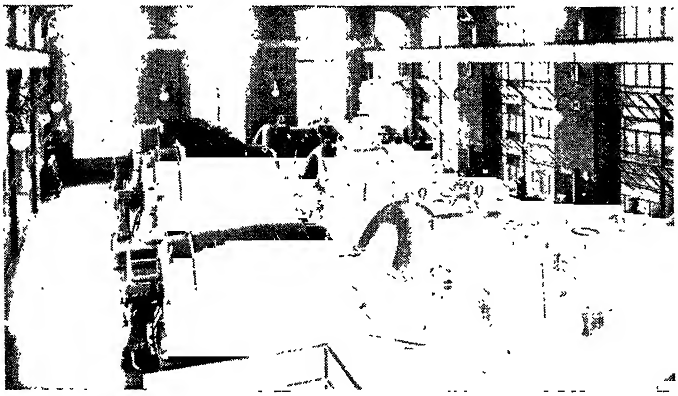
[19] Another estimate shows that in 1935 the available mechanical power in the United States amounted to 1.2 billion horsepower, or about 10 horsepower per capita. Since 1 horsepower is considered as the equivalent of 10 to 15 slaves, the available mechanical power amounts to 100 to 150 slaves per capita.—National Resources Committee, *op. cit.*, pp. 252, 262, 263.

[20] See Charles K. Leith, *World Minerals and World Politics*, McGraw-Hill Book Co., Inc., New York, 1931, p. 49, and Thomas T. Read, "The World's Output of Work," *American Economic Review*, vol. 23, March, 1933, pp. 58-59, and vol. 35, March, 1945, pp. 143-145.



A

Modern cement dam, also in the Missouri Ozarks. When there is rain, the dam holds the water until it is wanted and it passes through the turbines in the powerhouse at the lower left and the power goes away on a power line of which we see one tower at the lower right.



B

The dynamo room in a hydroelectric plant. Each of these units is several hundreds of times as effective as the dear old overshot watershed by the Ozark country mill.

TABLE 1

DISTRIBUTION OF WORLD POPULATION AND CONSUMPTION OF MECHANICAL ENERGY (1937–39 AVERAGE)

	Effective consumption all mechanical energy in quadrillions of foot-pounds	*Inanimate-slave population*	*Per cent of total world inanimate slaves*	*Human population*	*Per capita energy slaves*
United States	746	19,899,000,000	54	130,000,000	153
Canada	69	1,842,500,000	5	11,000,000	167
All other America	55	1,474,000,000	4	130,000,000	11
Total Americas	870	23,215,500,000	63	271,000,000	86
Germany (greater)	111	2,948,000,000	8	109,000,000	27
Great Britain	69	1,842,500,000	5	45,000,000	41
France	55	1,474,000,000	4	42,000,000	35
Italy	42	1,105,500,000	3	44,000,000	25
U.S.S.R.	69	1,842,500,000	5	169,000,000	11
All other Europe	55	1,474,000,000	4	157,000,000	9
Total Europe	401	10,686,500,000	29	566,000,000	19
Japan and China	83	2,211,000,000	6	557,000,000	4
All other Asia	0	0	0	567,000,000	0
Total Asia (except U.S.S.R.)	83	2,211,000,000	6	1,124,000,000	2
Total Africa	28	737,000,000	2	153,500,000	5
All other	0	0	0	10,500,000	0
Total World	1,382	36,850,000,000	100	2,125,000,000	17

The left column above gives comparative figures for effective world-energy consumption (average 1937–39), computed at 4 per cent efficiency. The column titled inanimate-slave population is arrived at by dividing the figures of column one by 37,500,000. This figure represents the foot-pounds of physical work that it is estimated a man may maintain over a year, less the energy required for self-locomotion. Countries whose animate and inanimate populations are under 1 per cent of the world's have been distributed proportionately to countries above 1 per cent (exception, Canada).

Source: Estimates by R. Buckminster Fuller in "U. S. Industrialization," *Fortune*, vol. 21, February, 1940, p. 163.

TABLE 2

THE WORLD'S OUTPUT OF WORK

	Millions of horsepower hours										Population, millions		Daily output per capita hp-hr.	
	Human		Coal		Petroleum		Water		Total					
	1929	1939	1929	1939	1929	1939	1929	1939	1929	1939	1929	1939	1929	1939
United States	40	43.8	1,001*	784.4*	481	617	121	166.7	1,643	1,611.9	122.77	131.41	13.38	12.27
Canada	3.3	3.7	55	39.6	17.6	25.4	59	104.8	134.9	173.5	10.35	11.02	13.03	15.74
Norway	0.9	1.0	3.6	4.6	0.6	2.57	15	26.5	20.1	34.7	2.65	2.94	7.58	11.80
Belgium	3	2.8	50	43.1	1.7	3.5	....	0.03	54.7	49.4	7.99	8.39	6.85	5.89
Great Britain	15	15.4	270	302.7	28.3	45.5	4	4.4	317.3	368.0	47.71	46.21	6.65	7.96
Germany	21	37.7‡	333	548.9‡	9.5	27‡	13	33.1‡	376.5	646.7	62.34	113.15‡	6.04	5.72
Sweden	2	2.1	7.5	14.4	1.9	5.3	16	20.4	27.4	42.2	6.12	6.31	4.48	6.69
Switzerland	1.3	1.4	3.9	5.4	1.0	1.3	11.5	24.4	17.7	32.5	4.02	4.21	4.41	7.72
France	14	14.2	127	101.0	12.3	25	24	43.2	177.3	183.4	40.74	42.42	4.35	4.32
Czechoslovakia	5	§	42	§	1.8	§	1.5	§	50.3	§	14.52	15.25	3.46	¶
Australia	2.1	2.2	10	26.0	10	7.4	†	2	22.1	37.6	6.43	6.96	3.44	5.40
Austria	2.2	§	12	§	0.9	....	6	§	21.1	§	6.67	7.01	3.16	¶
Union of So. Africa	2.3	3.4	16	25.5	1.8	3.7	†	.09	20.1	32.7	6.93	10.16	2.90	3.22
Holland	2.5	2.9	16	21.6	3.1	5.9	....	....	21.6	30.4	7.62	8.73	2.83	3.48
Poland	10	‖	48*	§	1.7	‖	†	§	59.7	‖	30.84	34.77	1.94	¶
Chile	1.5	1.5	2.0	2.7	3.8	2.7	1.0	1.8	8.3	8.7	4.36	4.63	1.90	1.88
Japan	21	24.3	52	¶	7	12.7	30	49.1	110	¶	62.94	72.80	1.75	¶
Argentina	3.6	4.3	4.5	¶	10	14.4	0.35	0.54	18.45	....	10.90	13.01	1.69	¶
Italy	14	14.7	23	20.1	4.6	10.9	27	50	68.6	95.7	41.17	44.03	1.67	2.17
Spain	7.6	8.5	13	10.5	1.8	2.85	8	11.2	30.4	33.05	22.75	25.37	1.34	1.30
Mexico	5.5	6.5	1.5	9.5	9.5	9.3	4.0	3.8	20.5	29.1	16.40	19.48	1.25	1.49
Hungary	2.8	3.7	6	17.1	0.8	1.0	†	.04	9.6	21.8	8.60	11.14	1.12	1.96
Rumania	6	6.7	4.1	3.9	6.8	7.5	0.8	1.0	17.7	19.1	17.39	20.09	1.02	0.95
Russia	53	56.9	56	219.7	35	85.3	4	15.3	148	377.2	158.50	170.47	0.93	2.21
Bulgaria	2.0	2.2	2.4	0.6	0.3		0.5	0.6	5.2	3.4	5.60	6.55	0.93	0.52
Yugoslavia	4.4	5.2	4.2	9.7	0.5		2	2	11.1	16.9	13.29	15.63	0.84	1.08
Peru	1.8	2.3	0.4	0.2	0.9	1.3	0.5	1.4	3.6	5.2	5.50	6.92	0.66	0.75
Brazil	13	14.7	3.4	2.2	3.0	4.4	6	8.9	25.4	30.2	40.27	44.12	0.63	0.68
India	106	117.8	34	40.3	8	8.2	3	5.0	151	171.3	318.88	352.84	0.47	0.49
China	133	161.1	43	55.1	4.13	3.4	†	....	180.13	219.6	400.80	482.30	0.45	0.46

* Includes natural gas.
† Quantities omitted; too small to be important.
‡ Includes Austria, Czechoslovakia and two-thirds of Poland.
§ Included in Germany.
‖ Divided between Germany and Russia.
¶ Data lacking.

Source: T. T. Read, "World's Output of Work," *The American Economic Review*, vol. 35, March, 1945, p. 144.

A train of oil tank cars creeps across the Great Plains where Lewis and Clark ventured as explorers in 1803. Indian and buffalo still held undisturbed sway in 1865. The buffalo has gone and the Indian has gone, the soil erosion map (Chapter 37) shows that much of the soil has gone. The oil will be gone presently and there are many who boastfully call this "progress."

graph, telephone, and radio. No human slave could work 24 hours a day throughout the year like a power-driven machine. A hundred years ago the interest on the investment in one prime slave in our South amounted to as much as $120 a year, to say nothing of the cost of upkeep. Today a mechanical horsepower, costing only $20 to $50 a year, substitutes for 10 to 15 human slaves.[21]

The prodigious consumption of inanimate energy in the United States calls for a word of explanation. In a country that has suffered from a shortage of labor throughout most of its history, man naturally has turned to the development and use of the power-driven, labor-saving machine. Because of our long distances, America also has become the world's greatest experiment in transportation. While the glories of our "wide open spaces" have been frequently extolled by poet, painter, and orator, in reality excessive space is a heavy burden upon American economic life. Each year we pay a terrific bill for transportation, since mobility is a daily and dire necessity. It cannot be assumed that each additional ton of coal burned under a locomotive boiler and that each additional gallon of gasoline consumed by an automobile yields a proportional increase in economic welfare or human happiness.[22] If this were true, we might well wish that the Appalachian and Rocky Mountains were twice as high and that the distance between New York and San Francisco were twice as great. The omnipresent automobile is not so much a sign of great prosperity as it is a moving example of our daily attempt to overcome the handicap of excessive space. The giraffe is not necessarily better off because it has a long neck. Our tremendous transportation system is long, and without it American economic life would be paralyzed. Yet this system involves a big investment,

[21] National Resources Committee, *op. cit.*, p. 262.

[22] See Erich W. Zimmermann, "Output of Work and Economic Well-Being," *American Economic Review*, vol. 24, June, 1934, pp. 239-249.

great maintenance and operation costs, together with a vast expenditure of energy. In 1935 automobiles consumed energy equivalent to 87 billion kilowatt-hours as compared with 92 billions used in central electric stations and 11 billions on farms. A large part of the available mechanical power in the United States is tied up in transportation equipment, as the following table indicates. And most of this equipment is idle much of the time.

TABLE 3

DISTRIBUTION OF POWER IN THE UNITED STATES, 1935

Electric central stations	44,670,000
Industrial power plants	20,133,000
Electric railway plants	2,500,000
Isolated nonindustrial plants	1,500,000
Mines and quarries	2,750,000
Agricultural prime movers	72,763,000
Automobiles, busses, trucks, and motorcycles	965,000,000
Airplanes	3,500,000
Locomotives	88,000,000
Marine	30,000,000
Total horsepower	1,230,816,000

4. *The Thinking Machine*

The age of power and machinery began its services to man by doing his manual labor for him. Later it began to do his brain work. Adding machines, accounting machines, and calculating machines have made much progress, but the *New York Times* of February 15, 1946, announces a revolution by telling of an erstwhile secret machine built to meet war needs.

It is the Electronic numerical integrator and calculator, "Eniac" for short. This device computes mathematical problems 1,000 times faster than it has been done before. The Eniac contains 18,000 vacuum tubes, has 500,000 soldered joints, occupies a room 30 by 60 feet, weighs 30 tons, took 30 months to build, required 200,000 man hours of work and cost $400,000.

It does not have a single mechanical moving part. It operates by electric impulses. They do the moving with the speed of lightning, or faster. It makes 100,000 electric impulses a second and uses 150 kilowatts of electricity. In two hours it solved a problem that would have occupied 100 men for a year. It multiplied 97,367 by itself 5,000 times in less time than it takes to wink—merely the pushing of a button.

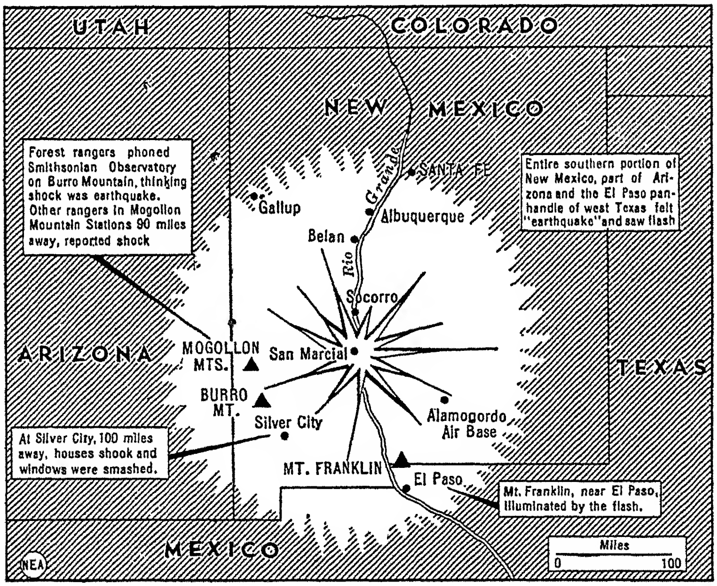
This thing is to the calculator with his pencil, about the same as the atomic bomb is to the yeoman with his bow and arrow. It will solve a whole host of basic problems, perhaps including long distance weather forecasting (one of the inventors is an amateur meteorologist). Engineers have often had to guess because it would take a lifetime to solve the problem accurately by old processes. Now they can instruct Eniac by a bunch of punched cards and push buttons, and the results will flash on the screen. It promises to be especially effective in machine design and in giving exact knowledge of moving bodies and substances. This may be as revolutionary for the future decades as electricity has been for those that are past.

This, apparently the summit of mechanism to date, arrives about 200 years after the steam engine opened the power age by the simple task of pumping water. It was created by two young men, J. Prosper Eckert, Jr., age 26, and John W. Mauchley, age 38. What will they do next? When one thinks of the means at their disposal, it appears that young

Thomas Edison, 65 years ago, was working in the stone age (almost)! The speed of scientific and mechanical discovery has increased greatly in recent years.

Problems of the Machine Age. Of long-run significance is the fact that the United States and other great industrial nations depend so heavily upon the fossil fuels for their supply of inanimate energy. It has been estimated that in 1939 about 46.9% of the total energy supply of this country, excepting human energy, was derived from coal, 31.5% from petroleum, 10.6% from natural gas, 5.5% from firewood, 3.4% from water power, 2.0% from animals, and 0.1% from windmills.[23] What is the fate of our proud mechanized civilization when the coal, petroleum, and natural gas are gone? Will some future Marconi perfect the long-distance transmission of power by radio thereby permitting man to use the huge water power reserves of interior Africa and the lesser ones of South America? Will some future Watt perfect a solar engine which will enable man to harness to his modern and complex machinery the inexhaustible energy of the sun?

As we have seen, every improvement of transportation and communication



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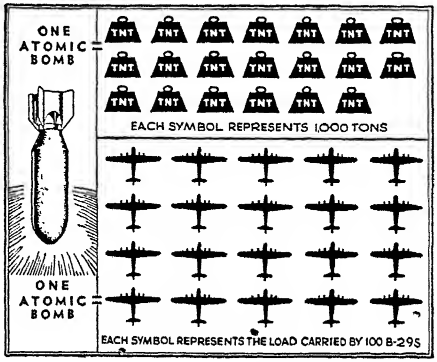
Here the atomic age announced its birth. At five o'clock on the morning of July 16, 1945, the world's first atomic bomb was exploded on the desert lands near Algomordo Air Base, New Mexico. The next month two bombs annihilated two Japanese cities and some hundreds of thousands of Japanese people, the war ended and the whole world shivered, and still shivers—and well may it. Who will be blown up next, by whom and when? Can we use atomic energy for good and not for evil? That is the most important problem that now faces humanity.

[23] Estimate by William M. Carpenter, Edison Electric Institute.—John George Glover and William Bouck Cornell (ed.), *op. cit.*, p. 603.

helps to bring the world's people, goods, and ideas closer and closer together. The darkest continental interiors now have some links with the outside world. Today, as never before in history, all nations, large and small, are dependent one upon another. Every cheapening of production brings more goods and services within the reach of the great mass of humanity, here and throughout the world. To some industries, regions, nations, and men the Mechanical Revolution brought great benefit; to others, little or almost none. It should be noted that some nations, through a wise use of available resources, have achieved much wealth, a good standard of living, and a high degree of human comfort without a lavish expenditure of inanimate energy and without the creation of a great power-metal economy. Sweden and Switzerland have no coal, Holland has no iron, and little Denmark has neither, but who would question their great material and social progress? The Mechanical Revolution has brought many changes, and it has never been an unmixed blessing.[24] The social revolutions that must follow mechanical revolutions are more painful than their prime cause. Its prime benefit has been to increase the productivity of human labor. Hence, the power-driven machine makes possible an economy of abundance, with more and cheaper goods and services available for human consumption and more time for human leisure. If the machine fails to bring about an economy of abundance, it is not the fault of the machine. Man has learned how to harness inanimate energy to his machinery, but he has scarcely begun to learn about harnessing the machine in the best service of man. Since inanimate energy plays such a vital role in the geography of today, we turn our attention to the world's great manufacturing and mineral industries.



© *New York Times*

One atomic bomb and its equivalent in 2,000 airplane loads of TNT.

[24] See J. Russell Smith, *The Devil of the Machine Age*, Harcourt, Brace & Co., New York, 1941.

. . . 3

The Fundamentals of Manufacture

1. Man in a Universe of Power

This universe in which man lives is one continuous carnival of power, a veritable saturnalia of power—physical power, energy.

If some supercyclopean hand should grasp this spinning ball, the earth, with force enough to stop its 25,000 miles per day rotation, the thing would split up into myriad pieces, a great dump of rock, with a little water and loose dirt far down out of sight in the mass.

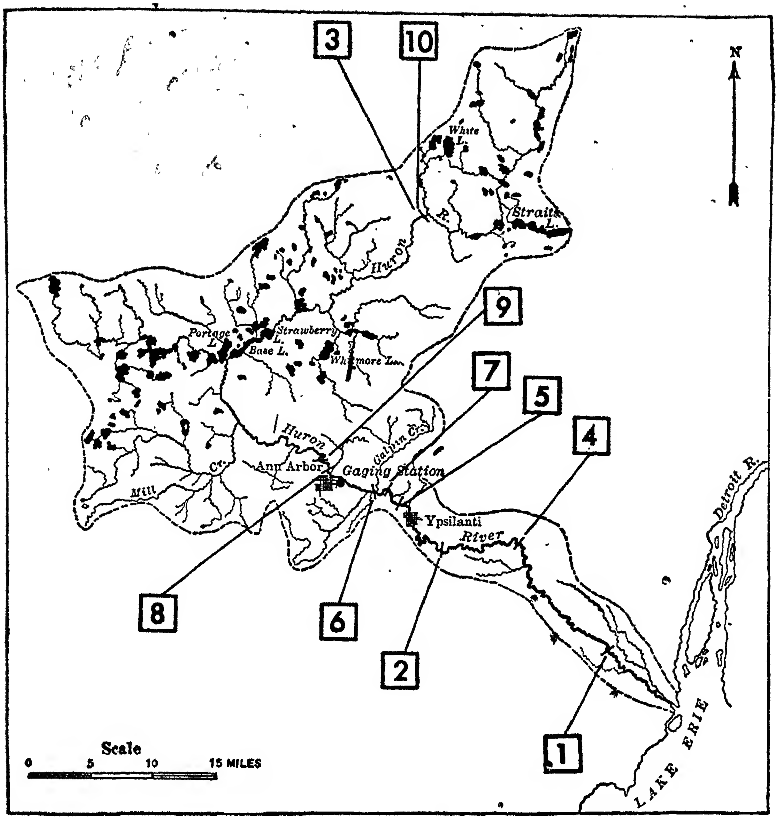
This earth speeds forward on its yearly journey around the sun at a rate of over a thousand miles a minute. If it should bump into a solid, unmovable object the force of impact would fuse the earth into molten lava in the first instant, and turn it into white hot gas in the second instant. The final conflagration pictured by the author of Revelation would be but a burnt match in comparison to this celestial flare—a new sun, gaseous, white hot and radiating heat rapidly into space.

Yet more. The earth rotating, revolving, is but a part of our solar system, the whole of which is flying headlong through space. Let us hope it doesn't bump into anything big. Every meteor is a little bump.

This solar system, rushing, revolving, rotating, with forces of inconceivable origin and inconceivable amount, carries with it an automatic power plant, the sun, which continuously hurls energy off into space. Of this heat and light the earth receives but a $1/1,200,000$ part, but see what it does for us! It supports all earthly life. By unequal heating of the different parts of the earth's surface it makes all the winds. The winds in turn blow the ocean into currents, make the waves to eat up continents, and continually pick up the waters of the sea, lift them high into the air, carry them away over the continents, and wearying of them drop them down as rain. We see a tiny scrimption of this wind power as the water runs back to the sea, and we talk about tens of millions of horsepower of water power.

What is man in this universe, with its saturnalia of power, endless, unmeasured, unmeasurable? Despite his splendid self-assurance, man is a very small creeper who lives in a narrow crack at the bottom of the air and the top of the earth. Narrow indeed is the crack in which the creeper must stay. He cannot go high into the air or deep into the earth—the earth where nature has wrenched and twisted, blown and beaten, piled up, worn down and spread out her leavings. After all it is only one of the lesser cosmic scrap heaps.

Here on this scrap heap the egotistic biped creeper is a kind of salvage man, continuously culling over the tailings of the universe, looking for scraps that he can use in his little games. For a long time, as he counts time, he got nothing but a few small third-hand products of



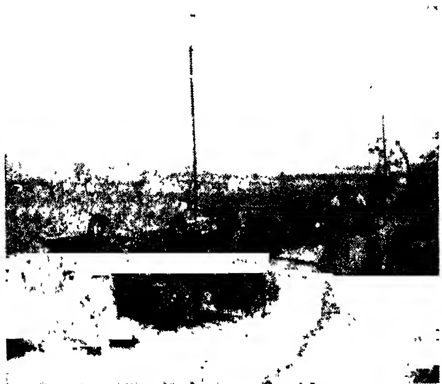
Drainage Basin of the Huron River, Michigan, showing the natural reservoirs created by Glacial Lakes (Newell). The power plants with owners and installed capacity (horsepower) are Ford Motor Company (1) 1,000, (2) 2,520, (3) 275; Detroit Edison (4) 3,200, (5) 1,150, (6) 1,200, (7) 1,800, (8) 1,150, (9) 2,065, (10) 375.

During the six year period 1939-44, the average production of power was approximately 31,660,000 kilowatt hours or 30% of generating capacity. The minimum (1941) was 25,900,000 or 25%, and the maximum (1943) was 49,400,000 or 47.7% of generating capacity.

The area of the catchment basin above Dam Number One is 780 square miles. Assume 75% of it in crop; 585 square miles or 374,400 acres devoted entirely to feeding horses. U.S.D.A. figure is 3⅓ crop acres per horse. This gives 113,454 horses. Assuming 80% of horse life at work, gives 90,763 horses working. Assume 85% efficiency (an estimate passed on by Bureau of Standards) and we have 77,184 horses. Assume 8-hour workday and we have 25,716 continuous real animal horsepower compared with 4,800 actually produced by the water power from this same land in an area of low relief. Add 1,000-foot descent from a plateau and the ratio between animal and water would probably have been reversed. As it is, the horses in this problem need to be discounted by the following factors, both heavy but not reduced to figures. (1) The horses on American farms utilize much pasture land in addition to cropped land. (2) Loss of power between the horse's shoulder and the functioning device.

Rough determination made by examining the U. S. Geological Survey maps shows the difference in elevation between the pond at the uppermost power plant and the tail water below the lowermost dam is about 300 feet. It is not all developed. One thousand feet or two thousand feet of fall added to this would make a great change in the total results.

energy—the plants and animals. Of late the implements of the hunt have improved and the catch has picked up greatly. Frequently now he finds a new scrap of power that he can use—a bit of breeze for his windmill, a bit of falling water, a few bits of dead moss (coal), some remains of dead fish and water bugs (petroleum and natural gas).



Photo—senior author

These coolies carrying big bundles of twigs of trees and pine needle fuel balanced on poles across their shoulder give several measures of poverty—poverty of fuel, poverty of transport.

He is wonderfully pleased with himself when he finds these things and he has a right to be, for they have entirely changed the conditions of life among the creepers in the crack. But the creeper has thus far been able to pick up only the tiniest of tiny crumbs that fall from the table of the universe—with its endless feast of limitless power. The big finds are yet to come—perhaps.

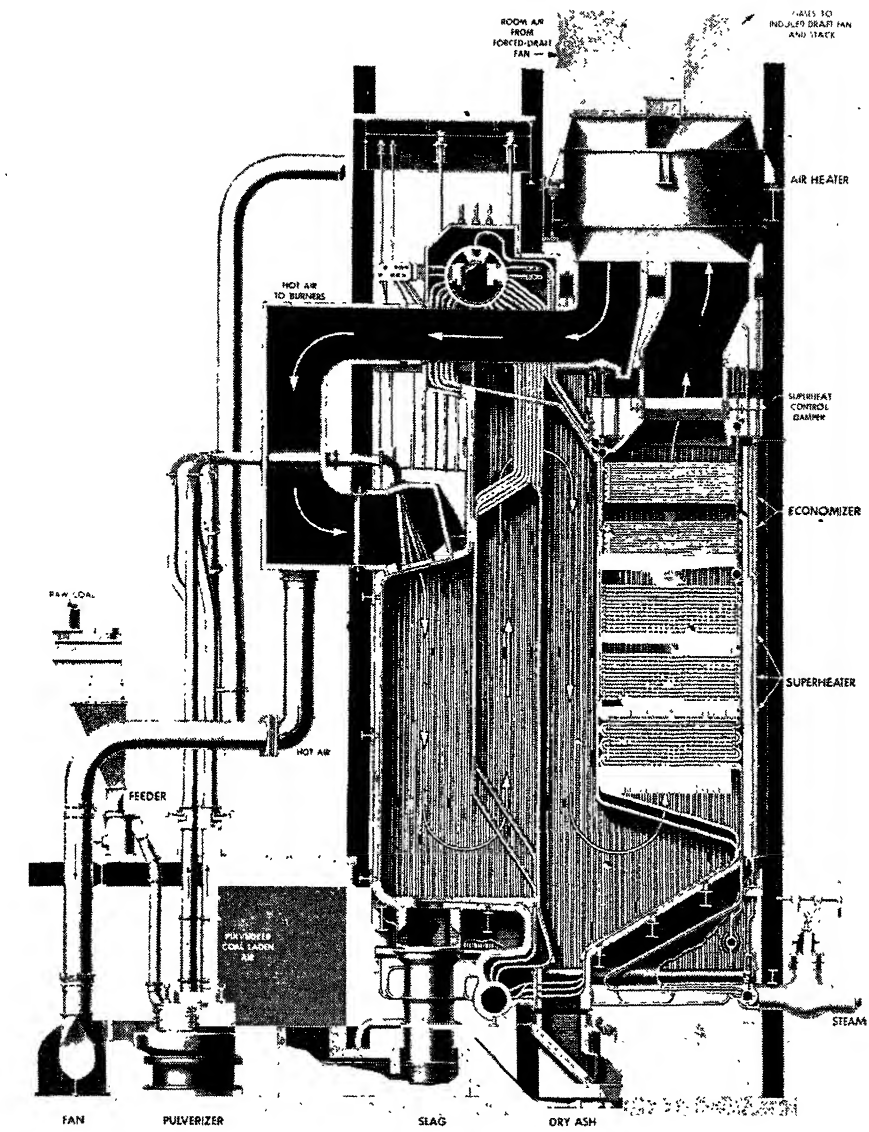
Alas! At last he has found a big one—atomic energy, so big it terrifies. A wave of terror has spread through the human race, a terror that terrifies the discoverers of atomic energy even more than it terrifies the rest of us, and the terror does not wane.

Without power, nothing on this earth can move. All work is merely energy manifest in time and space. All industries, indeed all forms of work, are directly dependent in the first instance upon some form of power. This may be manpower, animal power, wind power, water power, or the power derived from burning wood, gas, petroleum, or coal. Modern manufacturing, as we have seen, depends heavily upon the inanimate energy obtained from the fossil fuels and falling water, especially the energy derived from coal.

In order to carry on manufacturing, man must have access not only to power but to a market, to raw materials, transportation, labor, and capital. Hence, just as the position of the earth in the solar system at any time is the result of a balance of forces exerted by the sun, moon, the earth itself, and other planets, so the location of manufacturing is determined by a combination of forces and factors. While a discussion of particular industries will be postponed until later chapters, we may now consider the general nature of manufacturing and the common factors underlying its location and development.

2. *The Location and Development of Manufacturing*

Nature of Manufacturing. Perhaps the most elementary fact about the development of manufacturing is that wherever there are people there will always be some manufacturing. The woman who cooks a meal, the woman who makes some item of clothing for the family, and the man who builds a shelter are all manufacturers, for each is changing the form of some raw mate-



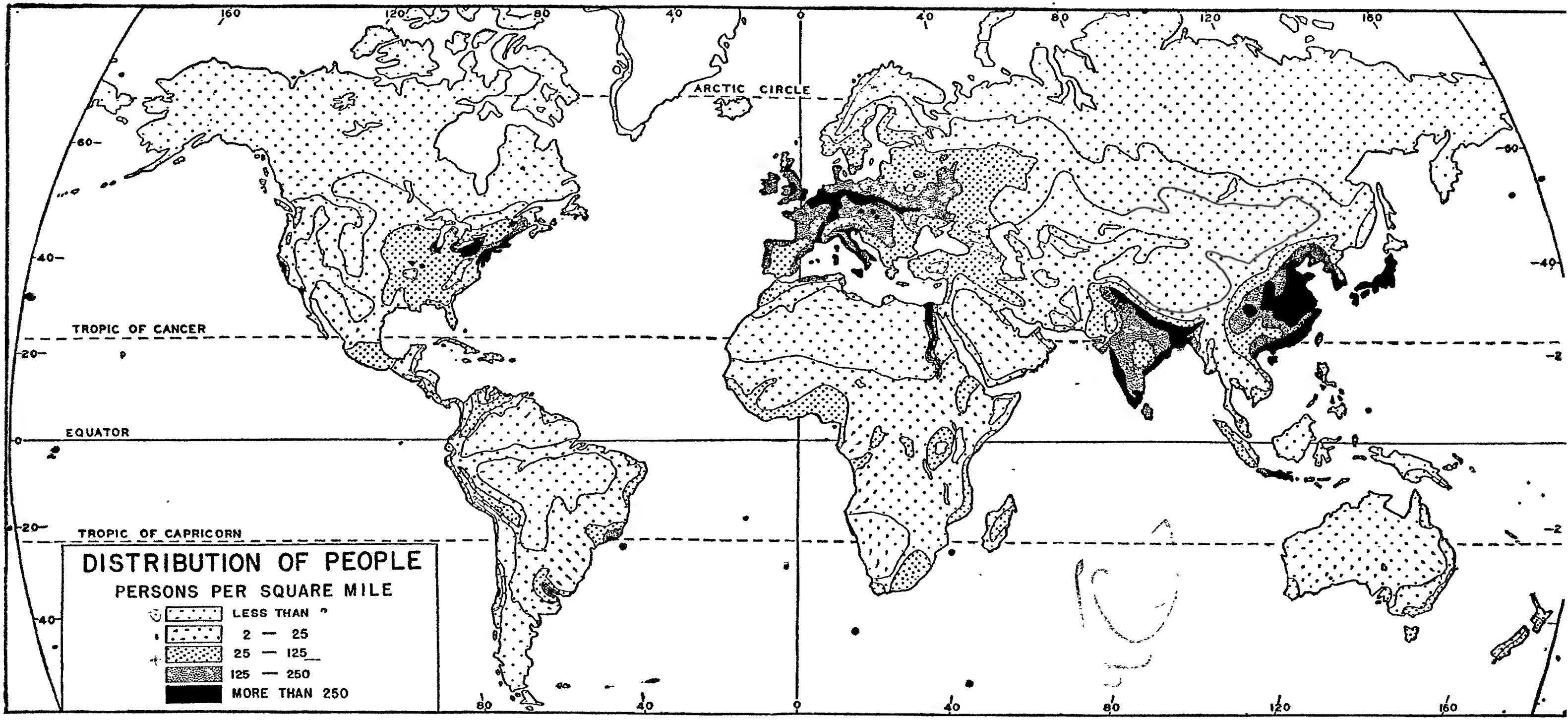
Modern boiler. Within recent years there has been great improvement in winning energy from fuel. In this boiler the coal comes in at the left center, feeds down to the pulverizer at left bottom, is ground to dust. The fan at left bottom drives hot air. The air is heated as it comes through the passage beside the boiler. This hot blast forces the coal dust up the pipes, where, slightly above center, it is blown into the fire chambers. It goes down, up, down, up and finally out at the upper right. Any ashes that are made fall to the lower right, are broken to pieces by jets of water and carried away in a pipe like sewage, finally sluiced into a barge for cheap disposal.

Compare this smokeless performance with the sweating stoker with his shovel, heaving coal on top of a fire which sends much good fuel into the air in the form of black smoke and unburnt gases to contribute to community destruction.

rial in order to make it more desirable for human use, which is the essence of all manufacturing. If goods are to be useful to man, they must not only be available when and where they are wanted but also in the form in which they are wanted, and the function of every manufacturer is to create this form utility. In the world of today we find all kinds of manufacturing, varying from the most simple to the highly complex. Manufacturing may be conducted on a large scale or on a small scale, it may be centralized or decentralized, it may require much or little skill and much or little capital, it may be mechanized or unmechanized, and it may be performed with or without the use of inanimate energy. It may be found in large factories or small factories, in little workshops, and in private homes. In every case, manufacturing develops in response to human need. In order to exist, manufacturing must compete successfully with other industries for the use of labor, capital, and land. In every case, the location and development of manufacturing depends upon a combination of fundamental factors. Sometimes one or two of these factors may be more important than others, but all are essential in order that manufacturing may develop and thrive.

Access to Market. First among the factors that are fundamental to the development of manufacturing is a market consisting of people with a desire for goods and the ability to buy them. Wherever there are few people and a high degree of isolation man must be a "jack of all trades," for the market is too small to permit much specialization and the development of manufacturing as a separate occupation.[1] In such sparsely populated and isolated areas each family must make nearly everything that it needs. Here one finds a primitive household type of manufacturing, the common articles of everyday life being made from local raw materials by hand with simple tools in the home. The finished products are generally used by the producer and his family or are occasionally sold or exchanged for other goods in the immediate locality. Such primitive manufacturing has been found along every frontier in history. It is found today among the Eskimos, the nomadic tribes of central and northern Asia, the forest peoples of interior Africa and South America, the mountain folk of rural Europe, and the mountaineers of southern United States. As the population increases, as villages and towns develop, and as transportation improves, man has a greater opportunity to trade, and the growing market permits some men with greater skill to set up small shops and mills and to devote their entire time to spinning and weaving, shoemaking, blacksmithing and other occupations that serve the community. Thus, the growth of the local market promotes specialization

[1] In 1776 Adam Smith pointed out that division of labor is limited by the extent of the market, and he observed, "In the lone houses and very small villages which are scattered about in so desart a country as the Highlands of Scotland, every farmer must be a butcher, baker, and brewer for his own family. In such situations we can scarcely find a smith, a carpenter, or a mason, within less than twenty miles of the same trade. The scattered families that live at eight or ten miles' distance from the nearest of them, must learn to perform themselves a great number of little pieces of work, for which in more populous countries they would call in the assistance of those workmen."—Adam Smith, *An Inquiry into the Nature and Causes of the Wealth of Nations*, Book I, Chapter III.



The world has three great masses of population—China-Japan-India, western Europe and a half mass in eastern North America. Outside of these small areas, a small fractic of the race scatters over the rest of the world. The final understanding of why population is so concentrated is an end result for a good course in economic geography.

In brief, it may be said that the Asiatic masses represent small farmers, living largely on vegetable diet in lands of monsoon rain. The European and American concentratioi depend upon manufacturing, far-flung trade, and imported food—unstable equilibrium.

and the development of workshops, mills, and other small manufacturing enterprises.

The development of manufacturing, therefore, depends upon man's ability to trade. This is limited by the extent of the market which, in turn, depends largely upon the density of population, the availability of transportation, and also upon the purchasing power of the people. Man may possess a great desire for goods, but without purchasing power he cannot buy.

In sparsely populated areas where the purchasing power per capita is high and where man enjoys the facilities of cheap and easy transportation there is little primitive, household manufacturing, since man can import from distant sources most of the manufactures that he needs. Small community enterprises are to be found in the widely scattered towns and villages, but the limitations of the market, the lack of labor, and the greater reward that capital finds in other industries and other places preclude the development of manufacturing on a large scale. Such is generally the case in the pastoral and agricultural regions of Australia, New Zealand, Argentina, South Africa, Canada, and the United States. Many a small modern mining camp today relies solely upon the airplane in an otherwise isolated area to bring in all supplies that are needed from the outside world.

In densely populated areas where transportation facilities are poor and where a low purchasing power per capita prevails, manufacturing remains decentralized in workshop and home. This is true of a large part of southern and eastern Asia, where millions of people are so poor that they must make by hand in their homes many of the things that they eat, wear, and use. In this land of teeming millions, manufacturing for centuries has been subsidiary to agriculture, which gets first choice of labor, capital, and land. While the typical workshop is small, the total output of handicraft manufacturing is large, since the huge population must obtain the necessities of life. Here in workshop and home have developed the skilled craftsmanship for which the Orient has long been famous. Wherever the steamship, the railroad, and the foreign trader have penetrated the Orient, many a handicraft industry has been ruined by the cheap machine-made goods imported from the Occident. Handicraft industry has also suffered greatly in those localities where modern factories with power-driven machinery have arisen. Because purchasing power is so low, individual purchases of factory-made goods are small and limited in variety, yet in the aggregate the market is large. Already modern manufacturing has developed in favored spots, and there is every indication that it will continue to spread.[2] If known mineral deposits in India and China are exploited extensively, the modern factory system may be developed on a large scale. If so, the economic and social consequences will be great. Millions of Chinese farm families are near to railroads or canals but they can buy but little factory stuff because they must use practically everything they grow. Therefore

[2] For an able account of the development of manufacturing in southern and eastern Asia, see Kate L. Mitchell, *Industrialization of the Western Pacific*, Institute of Pacific Relations, New York, 1942.

no money, and no purchasing power. Hence the hand loom survives.

Northwestern Europe and northeastern United States are the world's greatest producers of manufactured goods and at the same time are the largest markets for their own wares. Both of these regions had developed an important handicraft industry and a flourishing commerce before the Mechanical Revolution ushered in the new factory system with its power-driven machinery, for here were to be found the greatest urban markets of Europe and America. As a result of the Mechanical Revolution, both the population and wealth of these two regions grew enormously. In an ever expanding market, manufacturing, transportation, commerce, and finance developed rapidly, one stimulating another. Hence, within these two regions are found today dense populations, great mobility of goods and men, and a high purchasing power per capita, which combine to make the world's greatest markets for goods of every kind and description.[3] From the far-flung corners of the earth are brought vast quantities of foodstuffs and of raw materials for manufacture, and from the factories of these two regions are shipped innumerable finished goods to consumers in local and nearby markets and to men in many distant lands.

The market for goods and services is merely one of several factors that together determine the location and development of manufacturing, but this factor is of special importance to certain types of industry. Without attempting to analyze specific manufacturing industries, a few examples may be given of industries that are particularly sensitive to the "pull of the market." Among such industries are those in which transportation charges comprise a large part of the selling price of the finished product if it is transported very far, such as cement. If the sale of by-products is an important part of the business, as in modern meat packing, nearness to market is desirable. The production of shoe and textile machinery in this country is still centered in New England, where great shoe and textile manufacturing industries make the market for the machines.

Industries in which the process of manufacture increases the bulk are particularly pulled toward the market. This is true especially of agricultural machinery. Boxes and barrels are a glaring example. They come from lumber regions knocked down and packed solid, to be put together at the market town.

Obviously, the manufacture of highly perishable finished products, such as baked goods and ice cream, and various service and repair industries that must meet customers' specifications are conducted in the midst of the market.

Access to Raw Materials. A second factor that is fundamental to all manufacturing consists of access to raw materials. Patently, the manufacturer must have reasonably cheap raw materials or his costs of production may be prohibitive. With every improvement and cheapening of transportation, the manufacturer is able to reach farther for his raw materials as well as to serve more distant markets. The primitive house-

[3] In 1942 the people of the United States produced goods and services worth $154 billions as compared with $119 billions in 1941 and $99 billions in 1929.—National Resources Planning Board, *National Resources Development, Report for 1943*, Part II, Washington, 1943, p. 18.

A grab bucket reaching for its standard load of 15 tons of iron ore in the bottom of a Great Lakes ore carrier. The operator visible in the shaft of the machine, who operates by pulling levers, is Anthony Kozrowski—he shows the debt the American industry owes to Europe, which for generations has raised up people who came here to work for us.

Compare the speed, pain and load he lifts by pulling levers with the back-breaking work of the man with a scoop shovel of not so long ago.

hold manufacturer, located in a sparsely populated area that suffers from a low purchasing power per capita and a lack of transportation, obviously is forced to rely upon the use of local raw materials. In contrast with him, the modern manufacturer of northeastern United States and northwestern Europe can profitably use the products of field, pasture, forest, mine, and sea that may have been carried half way around the world to his factory door. Yet, in spite of the continued cheapening of transportation, certain types of manufacturing necessarily are located near to the source of raw materials. This is particularly true of simple manufacturing that makes use of low-valued, heavy and bulky raw materials, such as the manufacture of bricks from common clay, the ginning of cotton, and the sawing of lumber. It is also generally true of manufacturing based upon the use of bulky and perishable raw materials, such as the manufacture of butter and cheese from milk, the extraction of raw sugar from cane, and the canning of fruits and vegetables. If the finished produce is smaller and lighter than the raw materials, the location of raw materials is potent; for example, the turning of saw logs into lumber, or 7,000 pounds of ore,

fuel and flux into 2,000 pounds of pig iron.

Access to Transportation. The preceding discussion has already revealed that a third vital factor underlying the development of manufacturing is transportation, which so vitally affects the manufacturer's access to both raw materials and markets. The movement of goods in wagons or carts or on the backs of human porters is obviously slow and expensive. Since the coming of the steamship and the railroad, continuous improvement of mechanized modes of transportation has greatly reduced both the time and cost of shipping goods, thereby extending the market for the sale of manufactures and enlarging the radius for the assembly of raw materials. Hence, it is almost axiomatic that where transportation facilities are available and freight rates are low, commerce and manufacturing thrive. Fortunate is the manufacturer who is located within a well-developed and co-ordinated system of waterways, railways, highways, and airways facilitating the movement of all classes of freight. The great industrial-commercial regions of northwestern Europe and northeastern United States have the most highly developed transportation networks and the lowest freight rates in the world. No point within either region is farther than ten miles from a railroad.[4] Water transportation has always been the cheapest mode of transportation, and wherever available it greatly facilitates the movement of low-valued, bulky and heavy commodities that require economy of transport. It must be admitted that the speed-minded American has lagged behind the European in his appreciation and use of inland waterways. However, it is interesting to note that of the 25 largest cities in the United States in 1940 all but two are located upon navigable water; eleven of the 25 cities are seaports, the others being located upon inland waterways.[5] This is significant in view of the fact that railroads have always recognized potential and actual water competition by lowering their rates sufficiently to get traffic, an advantage accruing to the shipping public that is blessed with access to navigable water.

It should be emphasized that the mere existence of transportation facilities is no guarantee of low freight rates. Without attempting to analyze the complexities of rate making, a few observations of geographic and economic significance may be made. First, it does not cost much more to run a ship or a train several hundred miles laden with freight than it costs to run it empty. Second, since transportation is generally subject to the principle of decreasing costs, the greater the volume of traffic, the lower is the cost of moving a ton of freight a mile. These two facts simply mean that freight rates generally are low in those regions that produce a large volume and variety of traffic, especially if traffic moves in large volume in both directions along the route that is served by the ship or train. In regions that produce little traffic, and especially

[4] For a stimulating discussion of the railway patterns of the various continents, together with excellent maps, see Mark Jefferson, "The Civilizing Rails," *Econ. Geog.*, vol. 4, July, 1928, pp. 217-231.

[5] The seaports are New York, Philadelphia, Los Angeles, Baltimore, Boston, Washington, San Francisco, New Orleans, Newark, Houston, and Seattle. The cities on inland waterways are Chicago, Detroit, Cleveland, St. Louis, Pittsburgh, Milwaukee, Buffalo, Minneapolis, Cincinnati, Kansas City, Rochester, and Louisville. Only Indianapolis and Denver among the 25 largest cities are not located upon navigable water.

if traffic moves predominantly in one direction, freight rates are generally high. Over the long run, however, it may be said that the availability of transportation facilities tends to beget trade, manufacturing, and other industries, and reciprocally the growth of manufacturing and other industries provides increasing traffic that stimulates transportation and tends to bring about lower freight rates.

Access to Labor. A fourth factor that is indispensable to manufacturing, and indeed to every form of economic activity, is human labor. The greatest development of manufacturing occurs in the most densely populated regions, for here are to be found the largest market for goods and the largest supply of labor. In large urban centers land values are high, and man usually has the least opportunity to become a landowner, but here the opportunity to work for others is greatest. Here, too, the chance for specialization is greatest, and man finds a wide field of employment not only in different types of manufacturing but also in trade, domestic and personal service, clerical occupations, transportation and communication, and professional and public service. Modern manufacturing, with its large-scale production methods, power-driven machinery, and minute division of labor, offers employment to men with all types and degrees of skill, and many jobs of operating machines can be learned in a very short time. In countries with well developed, modern transportation facilities, the mobility of labor is greater today than ever before, and man has a chance to move to jobs that suit his taste and that offer the highest wages. Manufacturing, of course, must compete at all times with other industries for the use of labor. In this respect the American manufacturer of today is much better off than the manufacturer of a century ago who was confronted by a westward migration of men and their families who were staking their fortunes in the development of the vast, varied, and cheap natural resources of our continental interior. Since the frontier and man's opportunity to acquire good land at little or no cost have vanished in the United States,[6] since power-driven machinery is displacing both man and beast on many a farm, and since the inflow of European immigrants has dwindled to a mere trickle, the siren call of factory wages has lured millions of Americans from off the farm into the great urban centers. For the manufacturer, this movement of men to cities has a double significance, for it steadily increases the urban and suburban markets for his goods and at the same time provides him with a growing supply of factory labor.

While there is a great variation in the labor requirements of different manufacturing industries, there are certain types of manufacturing that are attracted by the presence of cheap labor. This attraction is especially important to those enterprises that operate on such a slender margin of profit that they must pay low wages in order to exist. The output of tailor-made clothes in European cities is much greater than in American cities largely because Euro-

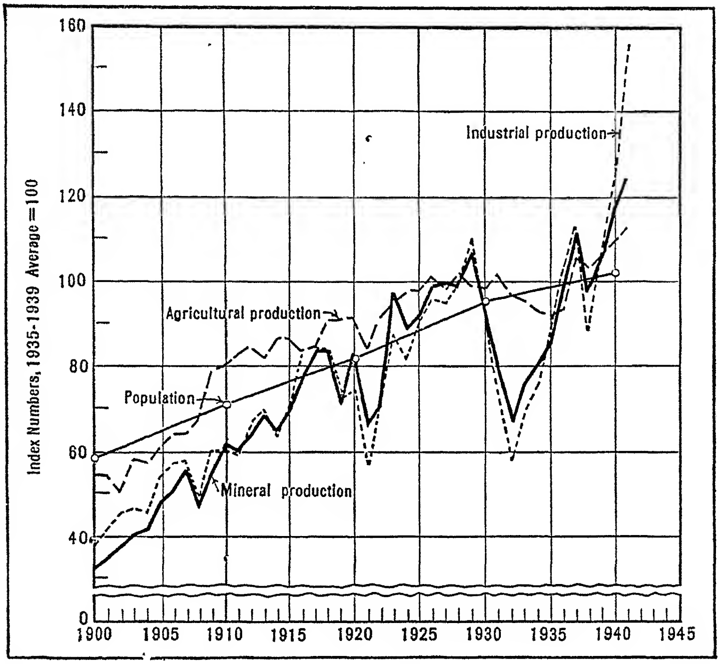
[6] See Frederick Jackson Turner, *The Frontier in American History*, Henry Holt & Co., New York, 1920, and J. Russell Smith and M. Ogden Phillips, *North America*, Harcourt, Brace & Co., New York, 1942, pp. 1-37.

pean labor is much cheaper. The production of Persian rugs and shawls and other articles of Oriental handicraft requiring long hours of cheap and skilled labor would be impractical in the United States, although clever machine-made imitations are produced here. The output of embroideries, lace, and other fine articles of the needlework trades under the American flag is confined almost entirely to the island of Puerto Rico, where a good deal of cheap labor is available. In the coal mining and cement manufacturing districts of Pennsylvania are to be found certain parasitic industries, such as silk and rayon mills that depend upon the cheap labor of the families of the coal miners and cement workers. The migration of the cotton textile industry from New England to the South was definitely a movement toward cheap labor that could be easily trained for work in the textile mills.

If skilled labor is an outstanding factor in production, the manufacturer who sets up a new factory is likely to be attracted to those areas where skilled labor is already available; as many a new manufacturer of automobile parts has gone to Detroit and other Michigan towns. When market and other factors lure the manufacturer far from an area with a well established industry, he finds it necessary to bring skilled labor from a distance to operate the machines and to train unskilled local labor, which is costly and requires time. Thus, skilled machine operators were imported from Massachusetts when new shoe factories were first set up in St. Louis and other midwestern cities, and skilled Pittsburgh labor was brought to Gary when the steel industry was first established there.

Access to Capital. A fifth factor that is indispensable to the development of manufacturing consists of access to capital, but this does not mean that the manufacturer must be near the supply of capital funds. An industry may be located with good reason near the market, raw materials, transportation facilities, labor supply, or power resources, but no industry today deliberately moves toward capital. The reason for this is simply that of all the factors contributing to the development of manufacturing, capital is the most mobile. In normal times capital funds flow freely from the great metropolitan centers of finance, such as London and New York, to the most remote and desolate spots in the world provided only that the capitalist finds there reasonable security and a good chance for an adequate return on his investment. On the other hand, a manufacturer in a big city can not borrow a dime from the bank around the corner, if his balance sheet shows that his enterprise is in a hopeless condition.

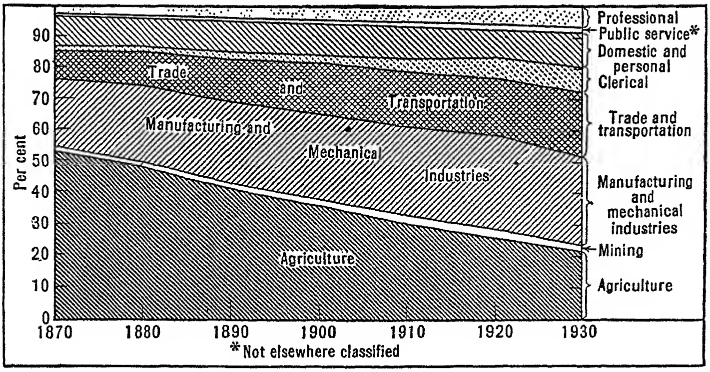
The availability of capital has obviously played a vital role in the development of manufacturing. The origin and rise of the factory system in Great Britain during the late eighteenth and early nineteenth centuries was greatly facilitated by the ready investment of profits that had accumulated from a prosperous overseas commerce and shipping together with the surplus funds of a long established handicraft manufacturing industry. In a similar manner, capital was readily available for investment in factories in New England when this region became the cradle of the American In-



Forty-one years (1900 to 1941) of growth in the physical volume of mineral production, agricultural production and industrial production and the numbers of people in the United States.

dustrial Revolution. Manufacturing, of course, must compete with other industries for the use of both capital and labor. That industry which promises to yield the highest profit obviously attracts capital most quickly. The United States, with its great variety and wealth of natural resources, has long had important and thriving agricultural, pastoral, forest, mining, and transportation industries, which in many instances during the nineteenth century yielded fabulous returns to both workers and investors. Patently, competition from such industries for the use of capital and labor was one reason for the later development of a widespread factory system in the United States than in Great Britain. It is also interesting to note that during the nineteenth century large amounts of British and other European capital were invested in American manufacturing, mining, transportation, and other industries and that it was not until World War I that the United States emerged from its debtor status and became a great capital lending nation. As the frontier vanished, as the opportunity for speculative profit in farm land, forests, and mines declined, and as this country has come of age, manufacturing has forged ahead until it has become the nation's leading occupation. (See Fig. 53.)

Access to Power. A sixth factor underlying the location and development of manufacturing consists of access to fuel and power. Where primitive manufac-



This graph gives us a chapter in industrial history by showing the change of the percentage of all persons over 16 years of age engaged in each of the major groups of occupations in the United States from 1870 to 1930.

As machinery has gone to the farm, a part of the farm population has been able to move to town or do the great work of transportation and participate in raising the material standard of living. Note the greater professional employment, greater clerical employment, and the evidence of increase of the effectiveness of machinery by the actual decline in proportion of those engaged in direct production of manufacture as well as agriculture. Unemployment is explained. A newspaper in Tibet, in the early 1930's, said the unemployment in the West was due to the use of wheels. Was it not correct?

turing occurs in household and workshop, the sole source of power may be manpower, such as that provided by the foot pedal which turns the spinning wheel or that supplied by the skillful fingers that send the shuttle across the hand loom. Manpower and manual skill are indeed the essence of the handicraft trades, which were so common in Europe and America prior to the coming of the Mechanical Revolution and which are still widespread in the Orient and many other parts of the earth. Again, the power may be that of the patient quadruped that plods its circular way around the ancient device which turns the wooden rollers that squeeze the juice from cane in the manufacture of crude sugar so commonly found in southeastern Asia and in the hill country of many Caribbean lands. Or perhaps the power for manufacturing may be the power of the wind moving the blades of a windmill that slowly grinds flour from grain. And, again, the power may be obtained by burning wood or the charcoal made from wood in forested areas where wood is cheap. Such sources of power are of considerable local importance, but the power of man, beast, wind, and wood are absolutely unimportant in modern manufacturing. The power-driven machines in the factories of today depend upon the inanimate energy derived from the fossil fuels and water power. The world's prime source of power is coal, which supplies more than two-thirds of the world's total mechanical energy. Coal is followed in importance by petroleum and water power, the production and use of natural gas being confined almost entirely to the United States and Russia. With unequaled access to power re-

sources, northeastern United States and northwestern Europe have become the world's greatest manufacturing regions.

Power, like labor and capital, has continued to gain mobility. The first factories in England to use power-driven machinery were the little textile mills equipped with simple water wheels that of necessity located the factories along streams. Likewise, the first factories in New England were located at water-power sites. With the perfection of the steam engine, power gained mobility, since coal, the source of power, could be hauled from the mine mouth to a more desirable point of use, a mobility that was made possible by the development of steam transportation. Yet, while coal could be moved cheaply long distances by water, it could not be moved far overland without greatly increasing its cost.[7] Among all countries, this transportation handicap was least serious in Great Britain, where coal fields are widely distributed, where overland hauls are short, and where the average distance from coal mine to seaport is only 25 miles. Yet even in this land of short hauls, nearness to coal producing areas was important, as is shown by the fact that all of the great manufacturing cities, except those in the London metropolitan area, developed within or very near the coal fields. Furthermore, once coal was delivered to the factory and converted into steam, the power had to be used on the spot, so each manufacturer was obliged to build and operate his own power plant. "For more than 100 years after the perfection of the steam prime mover by Watt transmission of power from the engine to the power-driven machines was entirely by mechanical means such as belts, chains, ropes, discs, cams, levers, gearing, and shafting. . . . While Watt's improvement of the steam engine marks the beginning of the Age of Mechanical Power, the greatest impetus to its use occurred in September 1882 when the Pearl Street electric generating station was started in New York City." [8]

As electricity proved to be an efficient power-transmission medium, power-driven machinery no longer had to be installed in close proximity to the steam engine or the water-power site, and today many manufacturers purchase electricity from great central electric stations far more cheaply than they could produce it themselves. The hydro-electric plant must be located at the power site, but the fuel plant generating electricity from coal, petroleum, or natural gas may be located advantageously in reference to the market.[9] Patently, every reduction in the cost of production of coal, petroleum, and natural gas and every cheapening of their transportation from the producing field to the power plant, every increase in the efficiency of steam and hydro-electric generating plants, every improvement in transmission technique, and every ex-

[7] In 1936 the average price of bituminous coal in the United States was $1.77 per ton, whereas the average revenue received by the railroads for transporting it from mine mouth to market was $2.25. In 1935 the average length of haul of bituminous coal by railroads was 188 miles, and that of anthracite was 116 miles.—National Resources Committee, *Energy Resources and National Policy*, Washington, January, 1939, p. 78.

[8] National Resources Committee, *Technological Trends and National Policy*, Washington, June, 1937, p. 254.

[9] So important is the "pull of the market" that the average distance traversed by the average kilowatt-hour from power house to consumer in the United States is only about 25 miles. Hydro-electric power generally travels much farther than power generated by fuel plants, for example, it is delivered by 284,000-volt lines from Boulder Dam to Los Angeles 300 miles away.

tension of inter-connection among electric power systems tends to increase the availability of power to man. While the long-distance transmission of electricity has limitations, the development of this new power-transmission medium has greatly increased the mobility of power derived from the mineral fuels and falling water.

The development of the electric power industry in the United States has been truly phenomenal, the output increasing from 2.3 billion kilowatt-hours in 1902 to 47 billion in 1922, and to 231 billion in 1944. Indeed, well over four-fifths of all the energy available to American manufacturers today is electrical energy. In 1937 this country led the world.[10]

	Billion kw. hrs.
United States	121
Germany	50
Russia	33
Canada	28
Japan	27
United Kingdom	23
France	18
Italy	15

This table is of great significance. Think of these facts in connection with Hitlers' great plan.

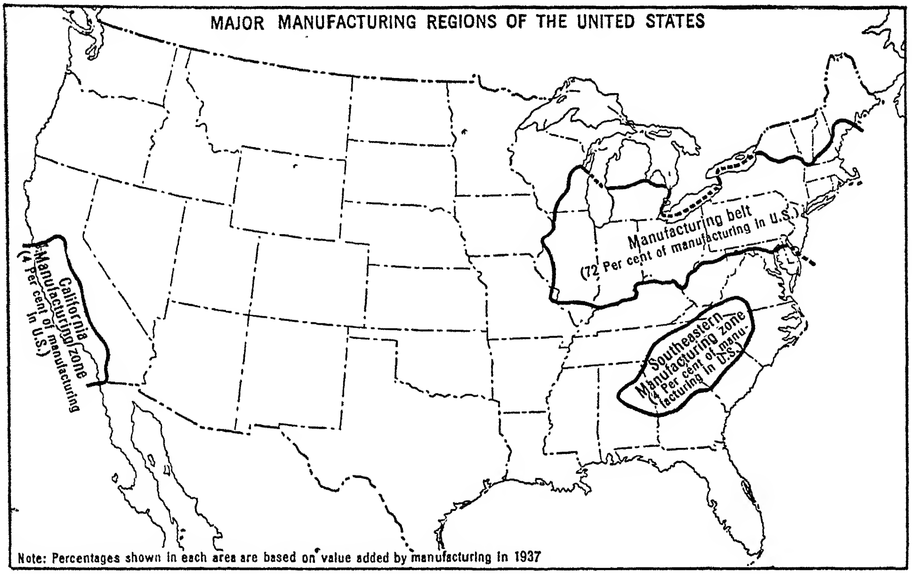
There is a considerable variation in the requirements of various manufacturing industries. Certain types of manufacturing are greatly attracted by the availability of cheap and abundant fuel and power. Nitrogen fixation plants, aluminum reduction plants, and pulpwood mills are among those that locate at water-power sites, where power is so cheap and plentiful. Accessibility to coal and coke is an important factor that enters into the location of iron and steel production, whereas the manufacture of glass requires an abundant supply of natural gas. On the other hand, in those industries in which other factors such as cheap labor are much more important than nearness to power, the electric power wire may bring in the power from a distant source. Such is the case of the cotton textile industry which has developed in many villages and towns scattered from Virginia to Texas throughout our South Atlantic and Gulf states. The coming of the power wire has probably been the greatest single factor permitting the decentralization of many manufacturing industries.

It is clear, therefore, that all manufacturing industries must have access to markets, raw materials, transportation, labor, capital, and power. Each of these factors is indispensable to the development of manufacturing, and in conjunction they determine its location. A specific manufacturing plant will be ideally located where in the long run total costs are lowest, all factors being considered.[11]

Miscellaneous Factors. Other factors, it is true, sometimes enter into the equation of industrial development. A stimulating climate that is conducive to human health and energy obviously facilitates manufacturing as it does all forms of human activity. Sometimes the location and concentration of a given industry in a particular city are the result of pure historical accident, as was the development of the automobile industry in Detroit, the manufacture of rubber in Akron, the kodak industry in Ro-

[10] No comparable data are available for these countries since 1937. Data for Russia are as of 1936.—U. S. Dept. of Commerce, *Foreign Commerce Yearbook, 1938,* Washington, 1939, p. 413.

[11] See Alfred Weber, *Theory of the Location of Industries,* University of Chicago Press, Chicago, 1929, and W. Gerald Holmes, *Plant Location,* McGraw-Hill Book Co., Inc., New York, 1930.

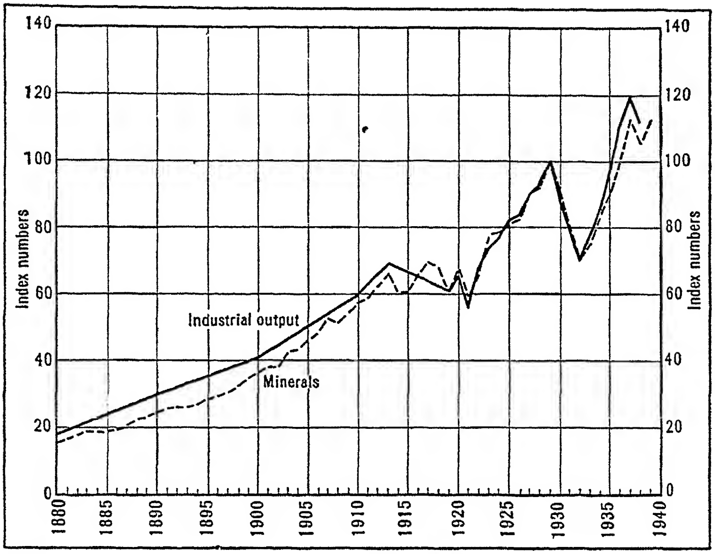


The major manufacturing regions of the United States. Note the great concentration, almost 75%, in a comparatively small northeastern section of the country, close to ocean, to coal and to lake and river transportation.

chester, glove manufacturing in Gloversville and Johnstown, N. Y., and the manufacture of shirts, collars, and cuffs in Troy, N. Y. It should be noted, however, that all these examples are in *good* locations for the particular industry. If Henry Ford had started tinkering with clocks at Bismarck, North Dakota, and had stuck it out there, his fame would have been local and short—the visionary who didn't make good.

Once an industry becomes entrenched in a given location, the momentum of an early start is often a potent factor causing it to remain there long after the original advantages have waned in importance; nevertheless, if the attractions of another location prove to be outstanding and of growing importance, it will eventually yield and migrate to the new and better location. "Momentum is the capacity of a body for 'going on' when once started—whether it be a train, or a business, or a town, or the Lancashire cotton industry, or the British Empire—and the greater the body is, the greater its momentum. . . . An engine does not at once stop dead if the steam is shut off, nor does it at once leap to full speed when the power is applied. In the long run the machine slackens and stops if there is not enough energy to keep it going, but it does not slacken all at once. The Roman Empire kept going for three hundred years after *its* energy was seriously reduced."[12] And so it is with all great manufacturing industries; it takes time for them to get started and often a long time for them to slow down and come to a dead stop.

[12] James Fairgrieve, *Geography and World Power*, University of London Press. Ltd.. London, 1932, p. 7.



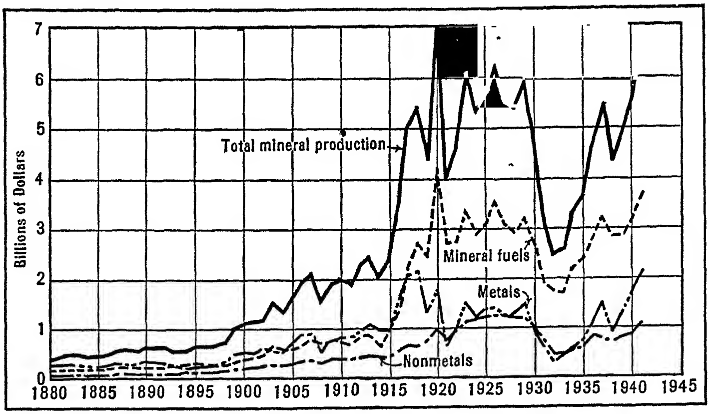
It is often said that this is the Age of Minerals and the great growth of industrial and mineral output of the world for 59 years gives striking proof. Index—1929 equals 100.

berian iron and steel center at Magnitogorsk.[13] The cost of such rapid industrial development cannot be measured alone in terms of statistics; it must also be reckoned in terms of the blood, sweat, tears, and privations of the Russian people. Yet, whether manufacturing develops as a governmental or private enterprise, its fundamental requirements are markets, raw materials, transportation, labor, capital, and power.

3. *Minerals and Manufacturing*

Importance of Minerals in Our Modern Machine Age. Through modern factories flows an endless stream of products from the animal, vegetable, and mineral kingdoms that bellow, squeal, and grunt, rumble and thud, roll, slide, pour, and dump, and that make dust, smoke, smell, noise, tonnage, values, jobs, wages, salaries, and profits as these products are converted from one form to another en route to the final consumer. Men and machines are directing and shaping this constant flow of products of field, pasture, forest, mine, and sea. Driving every machine is some form of power, without which all movement would cease. The power that gives rise to the whole production process is the inanimate energy derived from the mineral fuels and falling water. The machine that harnesses the power and converts raw materials into myriads of things wanted by millions of men is made of metal. Minerals, therefore, are the source of the machine and most of the power that is used to run it. Without minerals, there would be no power-driven machinery in manufacturing or

[13] For a dramatic account of the creation of this great iron and steel center, see John Scott, *Behind the Urals,* Houghton Mifflin Co., Cambridge, Mass., 1942.



This graph, indicating trends in the value of mineral production in the United States 1880 to 1941, shows again how minerals dominate our economics and how industrial depression knocks their value down by reduction in price and reduction in quantity produced.

in transportation, mining, farming, or any other economic activity. Without the power-driven machine, there would be no modern manufacturing. Our modern Machine Age is based squarely upon a mineral foundation, and the greatest pillars of strength in this foundation are coal and iron.

Long-run Trends in Mineral Production. Since minerals play such an outstanding role in modern economic life, a few salient features of mineral production will be considered. As the Mechanical Revolution got under way, man began to dig for mineral wealth as never before in all of recorded history. His continued diggings have brought to the surface a truly unprecedented volume and variety of minerals, a trend that has gained momentum down through the decades and spurted in World War II. Indeed, in the first four decades of the present century, man used more of the world's mineral deposits than in all preceding centuries.[14] In general, it may be said that the world's output of minerals has long kept pace with industrial production. As Figure 58 reveals, the world's industrial and mineral outputs increased sixfold during the period, 1880-1939, trebling during the first half and doubling during the latter half of this period. Since the bulk of the demand for minerals comes from manufacturing and transportation, mineral production is subject to the same fevers of prosperity and chills of depression that cyclically afflict modern industry. Yet the long-run trend of mineral output continues upward. However, there is eventually a day of reckoning when man will reach the end of the rope, since nearly all sources of minerals are exhaustible.

In view of the exhaustibility of mineral deposits, their life cycle of production includes stages of growth, maturity, decline and usually death. Since reserves

[14] Charles K. Leith, James W. Furness, and Cleona Lewis, *World Minerals and World Peace,* The Brookings Institution, Washington, 1943, p. 1.

are still adequate and new discoveries are being made, it may be said that mineral production in the world as a whole and in the United States is still in the stage of rapid growth.[15] On the other hand, with approaching depletion of reserves, the mineral output of Great Britain and certain other European countries with long established mineral industries has entered the final stage of decline. The production of such new minerals as chromite, magnesium, and molybdenum is obviously in the stage of early and rapid growth, whereas the output of many older minerals is no longer increasing as rapidly as it did several decades ago, and the number of dead mines is appalling. As mining penetrates deeper into the earth and as reserves approach depletion, the cost per unit of output increases. Hence, the output from any mineral deposit in time will slacken in its rate of increase and then decline and eventually cease.

In the case of particular minerals, the long-run tendency for production to slow up and then decline may be accelerated or retarded by forces beyond the control of the mineral producer. The tremendous increase in demand for many minerals during World War II greatly speeded up their life cycle of production and hastened their day of exhaustion. The scientist, who so often is both hero and villain, is continually finding substitutes. Such progress is pleasing to the manufacturer and other consumers, but it may put a particular mineral producer out of business. Thus, the producers of sodium nitrate in Chile were nearly ruined by the competition of synthetic nitrate obtained from the air, coal, and other sources. Again, the scientist is always finding ways to increase the efficiency of mineral use, which greatly benefit the manufacturer and other consumers but which represent a decline in demand to the mineral producer and may cause him serious problems. Thus, new alloy steels not only meet the needs of consumers better, but they require less iron and last longer. Since 1920 improvements in refining technique have more than doubled the gasoline obtained from a barrel of petroleum, and greater efficiency in the use of coal has curtailed consumption per unit of output 56% in electric public utility power plants, 34% in steam locomotives, and 20% in pig-iron blast furnaces.[16] Furthermore, as a region's manufacturing grows larger and older, junk piles and scrap heaps increase in importance, since from them are salvaged larger and larger amounts of secondary or scrap metal that can be used again in production. During the depression years, 1930-35, more than 80% of all copper sold in the United States was of secondary origin, and prior to World War II about 50% of all iron used in steel manufacture was scrap iron.[17] While technological improvements that reduce the rate of mineral consumption may create serious problems for the mineral producers, they obviously benefit the consumers of today and those of posterity.

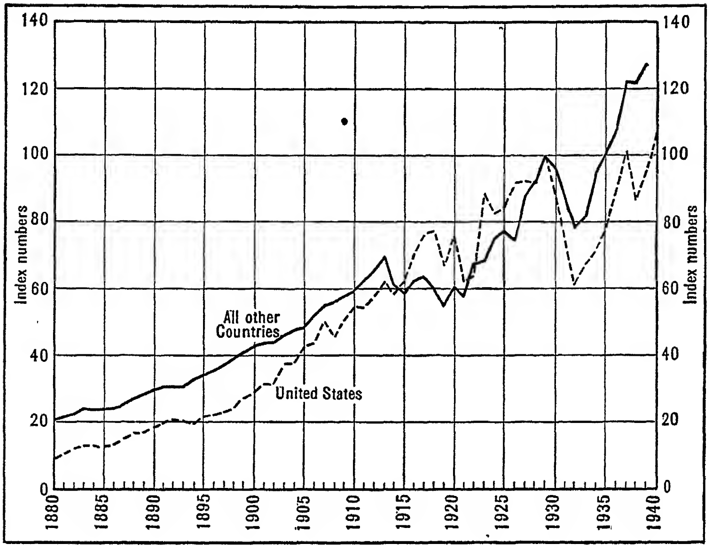
Another outstanding trend in mineral production has been the shift from small rich deposits to large ones that may contain leaner ores.[18] In the days

[15] Charles K. Leith, James W. Furness, and Cleona Lewis, *op. cit.*, pp. 18-19.

[16] *Ibid.*, pp. 20-21.

[17] *Ibid.*, p. 19.

[18] See Charles K. Leith, *World Minerals and World Politics*, McGraw-Hill Book Co., Inc., New York, 1931, pp. 6-11.



Mineral production of the United States 1880 to 1940 compared to that of all other countries shows the riches, as well as the industrial development, of the United States, and partially explains how we so utterly astonished the Germans and the Japanese by the production of war material in World War II. Index—1929 equals 100%.

of pick and shovel, the individual miner or small mining enterprise usually preferred the most accessible deposit with the richest and purest ore, and the relatively small demand for minerals in those days could be readily supplied from a large number of small and scattered sources. Today, however, the enormous demand for minerals calls for large-scale mineral production. The giant mining corporation, frequently affiliated with great manufacturing and other mineral consuming industries, has a tremendous investment in heavy and expensive mechanical equipment that can not be dismantled and moved about except at great cost. Hence, the big mining corporation tends to concentrate its operations in those mineral fields where reserves are largest, even though they may lack the richness, purity, and accessibility of smaller deposits. This development of large-scale mining operations converging on the largest mineral reserves has been part and parcel of the growth and integration of big business, a development that generally has brought about a lower cost of mineral products for the manufacturer and other mineral consumers.

Concentration of Mineral Production and Consumption. Finally, it should be emphasized that a remarkably large portion of the world's mineral production lies under the control of a very few nations. Of the total value of the world's mineral output in 1939, about 34% was produced in the United States, 23% in the British Empire, 10% in Russia, 7½% in Germany, and 6% in

the United Kingdom.[19] For decades the Americans and British have been the leading exploiters of minerals, and, if their ownership of mineral production in foreign countries be considered, it is probable that they control three-fourths of the world's total output of minerals.[20]

As the Mechanical Revolution gave rise to the factory system in Great Britain, northeastern United States, and western and central Europe, it was from these areas that came the increasing demand for minerals, which in time caused the industrialists of these regions to reach into distant lands for a greater volume and variety of mineral supplies. Today we find a gigantic power belt extending from the Mississippi Valley eastward across the United States, Great Britain, western and central Europe, onward into European Russia and Siberia. Within this belt is consumed more than 90% of the industrial energy derived from coal, petroleum, and water power. While this power belt is by no means a continuous manufacturing region, nevertheless within this belt is to be found the most important and highly developed manufacturing on earth, including more than 90% of the world's pig-iron and steel producing capacity. In contrast with this North Atlantic power belt, the entire southern hemisphere produces less than 3% of the world's coal, petroleum, and water power, and it has less than 2% of the world's iron and steel industry and an almost equally low percentage of other mineral consuming industries.[21]

While manufacturing centers are arising in favored spots in Japan, China, India, Australia, South Africa, Brazil, Argentina, Chile, and elsewhere (see Fig. 15), none of these outlying centers possess the favorable combination of markets, raw materials, transportation facilities, labor, capital, and power resources that are to be found in such a supreme degree within the North Atlantic power belt. "For a long time to come, the mineral resources of all the world will be mainly tributary to the industrial countries of the North Atlantic. Moreover, it is now pretty certain that the heavy industry of the outlying parts of the world will never catch up with that in the centers already established. This is because the basic supplies are not there on the scale available to the established industries of the North Atlantic. The industrial countries within the power belt must exchange minerals among themselves, and will continue to reach out to all parts of the world for additional supplies. The countries outside this belt will contribute whatever mineral supplies they have, together with other raw materials, in exchange for manufactures." [22] Thus, it is apparent that from nature's great geological lottery a few nations were given easy access to peerless energy and machine resources, an advantage that has placed in their hands so much wealth and political power. This is probably the most important single fact in the geography of modern times.

[19] Charles K. Leith, James W. Furness, and Cleona Lewis, *op. cit.*, pp. 224-226.

[20] *Ibid.*, p. 42.

[21] *Ibid.*, p. 32.

[22] *Ibid.*, p. 33.

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Coal: Prime Source of Energy and Basic Raw Material

1. The Origin and Importance of Coal

The Formation of Coal. Some two hundred and fifty million years ago much of the world was warm and damp and green. In vast tropical-like swamps was to be found a most luxuriant growth of vegetation, including thousands of species of plant life varying from minute algae to giant ferns and huge trees. The air teemed with spores of plants and buzzed with a profusion of insects, and great dragonflies darted hither and yon. Shallow pools abounded with fish life. Lizard-like three-eyed amphibia slithered into and out of the water. Some 800 species of cockroaches scampered about with no human hand or foot to molest them. In this swampy environment coal was being formed. As the plant life breathed in the carbon dioxide from the air and assimilated the carbon, the first step in coal making occurred. As the leaves, stalks, bark, and wood fell into the water, acids were formed that arrested further decay of organic material. As the remains of plant and animal life accumulated on the swamp floor, the debris below in the form of peat was compressed, and some of the water was squeezed out.

After the earth's surface submerged, a layer of sand, clay, or lime was in time deposited upon the peat bed. The pressure of these sedimentary deposits squeezed out much of the water, fats, and gas, and, together with heat and chemical changes, transformed the peat into a harder substance of higher carbon content, or coal. When the earth's surface emerged later, another jungle grew, resulting in the formation of another layer of swamp vegetation which went through the same peat and coal forming process. Thus, through repeated submergence and emergence of the earth's crust, nature made a colossal "club sandwich," with layers of coal alternating with other sedimentary rocks. Sometimes the pressure was later increased by folding or warping of the earth's crust, and the result was a harder type of coal.

It is estimated that about 400 feet of compact vegetable debris were severely compressed to make anthracite coal 50 feet deep in the Mammoth Bed of the Schuylkill Field in eastern Pennsylvania. The geologist is a shrewd detective always searching for clews, and with the naked eye he can sometimes see the imprints of leaves and stalks in a lump of coal. With his microscope he can see plant-cell structures. He knows that coal is preserved and compressed vegetation that once lived and breathed the carbon dioxide out of the air in a swampy environment a long time ago.

The man standing on the face of the cliff which forms one bank of a river in the Great Plains lignite coal fields serves as a standard of measurement for the black coal seam above him. Immediately behind the man are thin streaks of coal in the earth material. Granted sufficient time, the material on top of the thick seam would have become rock and the lignite one of the higher forms of coal. In its present form, it is one of the great reserves of the future.

The process of coal formation was exceedingly slow, and under the most favorable conditions it required 300 to 400 years to create a foot of coal.[1] In some places the process has been under way such a short time that only peat has been formed. This brown, fibrous, unsolidified substance is not even classified as coal. When dug out of a bog, it contains about 85% water, 10.4% volatile matter, only 4.6% carbon, and a variable amount of ash.[2] It must be dried before it can be burned, and even then it yields a lot of smoke and little heat. This poor fuel is used in some parts of Ireland, Germany, Poland, and Russia, but its industrial importance is negligible. Coal is peat that has been subject to additional pressure. It was the pressure involved in coal making that primarily determines the quality and types of coal available to man today. In general it can be said that the greater the pressure, the harder the coal, the higher the fixed carbon content, and the lower the amount of moisture and volatile matter. Hence, we find in order of increasing hardness three main groups or classes of coal, namely, lignite, bituminous, and anthracite.[3]

Types of Coal. Lignite is the softest and lowest type of coal, and it varies greatly in quality from place to place. This brown, woody coal contains the largest amount of moisture and volatile matter and the least amount of carbon among the various classes of coal, and it ranks lowest in heating value (see Fig. 66A). It cannot be handled much without crumbling, and it cannot be

[1] National Resources Committee, *Energy Resources and National Policy,* Washington, January, 1939, p. 43.

[2] H. M. Hoar, *The Coal Industry of the World,* U. S. Dept. of Commerce, Washington, 1930, p. 8.

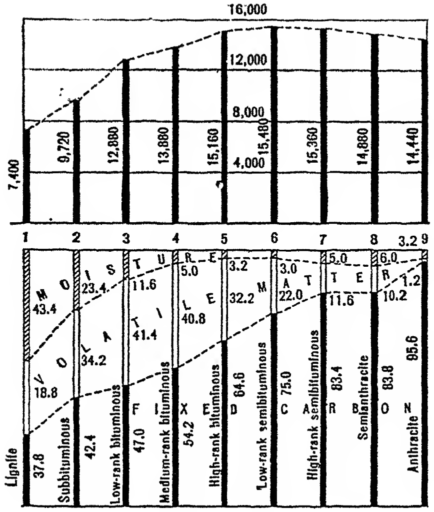
[3] It should be emphasized that each class and grade of coal shades almost imperceptibly into another and that no distinct or absolute line of demarcation can be drawn between them. In the commercial coal markets of the world thousands of grades of coal are recognized. In the United States geological and engineering authorities now subdivide coal into thirteen major types. See National Resources Committee, *op. cit.,* p. 57. For a summary of the characteristics of different ranks of coal, see International Labour Office, *The World Coal-Mining Industry,* vol. 1, League of Nations, Geneva, 1938, pp. 18-19.

The interior of an American bituminous coal mine with a hard rock roof supported by timbers. In the center we are looking down the length of a train of coal cars running towards the mine's mouth.

stored long without danger of spontaneous combustion. Because of these qualities and its general low value, lignite is seldom transported far from the mine. In Germany electric power plants located in the lignite fields make extensive use of this fuel. Over half of the German output is manufactured into briquettes, thereby reducing the moisture and doubling the heating value per cubic foot. These briquettes and raw lignite are commonly used for industrial and household fuel. Lignite is also an important raw material in the German chemical industries, which recover oil, tar, gas, and wax as by-products of distillation. In terms of bituminous coal equivalent, about 60% of the world's lignite is mined in Germany, most of the remainder being produced in Czechoslovakia, Russia, and Hungary.[4] A slightly higher type of coal than brown lignite is subbituminous coal, or black lignite, which is sometimes used for heating homes and occasionally as fuel for locomotives and other steam engines.

At the other extreme from lignite is anthracite, the hardest of coals which is usually found where folding and warping of the earth's crust provided the greatest pressure in the coal formation process. As Figure 66A indicates, this brilliant black coal has a carbon content of about 95% and very little moisture and volatile matter. In contrast with lignite, it does not ignite easily, but it holds its fire well, gives off great heat with almost no smoke or gas, and leaves very little ash. These qualities make anthracite an ideal household fuel, which is its principal use. Of the world's output of anthracite, over half is mined in the United States, more than one-fourth in Russia, and most of the remainder is produced in Belgium, Great Britain, Germany, and French Indo-China. A slightly lower

[4] About 4½ tons of German lignite are considered to be the equivalent of 1 ton of bituminous coal; in Czechoslovakia the ratio of lignite to coal is 1.7 to 1; in Hungary, the United States, and most other countries the ratio is 3 to 1.—International Labour Office, *op. cit.*, p. 57.



A

The lower graph shows percentages of fixed carbon, volatile material, and moisture in different grades of coal. The upper graph gives the heat efficiency of the same grades.

B

An anthracite coal breaker in eastern Pennsylvania. Pennsylvania anthracite is marketed by one of the tightest combines in American industry (which has too many), but the conditions of mining make it costly. Bits of slate are often imbedded in the coal and the coal often adheres to adjacent slate. It must be broken and sorted by hand or by expensive machinery in an expensive building called a breaker. Back of the breaker is a mountain of waste called culm. Improvements in burning the coal have caused many of the culm banks to be reworked to reclaim the refuse of past decades.

type of coal is semianthracite, which is used for domestic heating and also as fuel for steam engines and other industrial uses.

Between the extremes of lignitic and anthracitic coals is a broad class or group of bituminous coals that vary greatly in moisture, volatile matter, and fixed carbon content and which consequently possess a wide diversity of use.[5] For example, the semibituminous coals are preferred as bunker coal for steamships, since they contain little moisture and volatile matter and rank highest in heating value per ton, such features being desirable aboard ship where all available space is needed for cargo. On the other hand, the high volatile coals are obviously the best for the production of artificial gas, and some of them can be used in the manufacture of coke, the volatile matter yielding many by-products. Four countries usually produce over ~~three-fourths of the world~~'s output of bituminous coal, namely, the United States, Great Britain, Germany, and Russia—the American share being over one-third of the world's total output. If the tonnage of lignite be reduced to its bituminous coal equivalent, it is interesting to note that ~~of the world's~~ total production of coal in 1936 87.7%

TABLE 4

THE WORLD OUTPUT OF ENERGY SUPPLY, 1913–35

Year	*Anthracite and bituminous coal*	*Lignite*	*Petroleum*	*gas*	*Firewood*	*Water power*	*Total*
			In million metric tons of equivalent coal				
1913	1,216	46	77	24	300	40	1,703
1925	1,185	66	213	46	250	75	1,835
1930	1,217	70	281	69	250	102	1,989
1935	1,112	73	323	75	250	131	1,964
			Percentages of total supply				
1913	71.4	2.7	4.5	1.4	17.6	2.4	100
1925	64.6	3.6	11.6	2.5	13.6	4.1	100
1930	61.1	3.6	12.6	3.5	14.1	5.1	100
1935	56.6	3.7	16.5	3.8	12.8	6.6	100

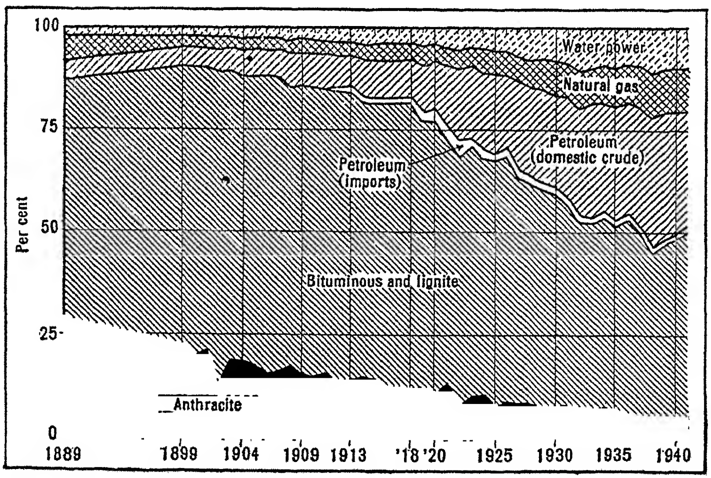
Source: Institut für Konjunkturforschung, *Energiequellen der Welt*, Berlin, 1937, p. 19, cited in International Labour Office, *The World Coal-Mining Industry*, vol. 1, League of Nations, Geneva, 1938, p. 32.

[5] For a discussion of the uses of the principal types of coal, see *ibid.*, pp. 20-24, and H. M. Hoar, *op. cit.*, pp. 298-300.

was bituminous, 7.6% was anthracite, and only 4.8% was lignite.

A Fundamental Resource. The importance of coal in the world of today can scarcely be overemphasized, for as one authority observes, "Of all the resources which are basal to our existing civilization, the possession and utilization of coal must be placed first." [6] As we have seen, it is the possession and use of inanimate energy that so greatly increases the productivity of human labor and places so much wealth and political power in the hands of a few nations. In spite of the spectacular development of petroleum and water power in recent decades, coal remains the world's prime source of energy (see Table 4), providing the great bulk of the heat, light, and power used by man today. Coal provides about 90% of all the inanimate energy used in Great Britain and Germany and about 70% of that consumed in Russia. In the United States the development of vast petroleum, natural gas, and water power resources has caused a great decline in the relative importance of coal since 1900 (see Fig. 68), yet coal still furnishes about half of our inanimate energy supply. Furthermore, it has been estimated that about two-thirds of the world's total daily output of work is accomplished through the use of coal [7] (see Tables 2 and 6).

All the modern nations have at their disposal mechanical power, chiefly coal, which far outranks the combined muscular force of all the men and all their beasts. According to one estimate, not



Percentage of total heat or heat equivalent contributed by the several sources of energy in the United States. Water power is counted as a constant fuel equivalent. Tremendous improvements in the efficiency of coal consumption have been made during this period. If the water power is counted at the prevailing fuel equivalent at central stations in each year, its proportion is 3.2% in 1899, and 3.4 in 1941; the proportions of other sources of energy would be affected accordingly.

[6] Edward Charles Jeffrey, *Coal and Civilization*, The Macmillan Co., New York, 1925, p. 2.

[7] Thomas T. Read, "The World's Output of Work," *American Economic Review*, vol. 23, March, 1933, p. 59, and vol. 35, March, 1945, p. 144.

more than 5% of the world's daily output of work is performed by draft animals, and the amount of work done by coal alone is at least five times that accomplished by human labor.[8] In the United States at least 35 units of mechanical energy are used for every unit of human energy, coal providing about half of the mechanical energy supply. As a result of the rapidly increasing use of mineral fuels and water power, the productive capacity of man was increased 50 times in this country between 1900 and 1935. Indeed, in 1937-39 the average amount of energy consumed by power-driven machinery utilizing the energy of mineral fuels and water power was equivalent to the work of approximately 20 billion slaves.[9]

If some wizard should, upon the first moment of some incoming year, banish all coal from the world, instant darkness would settle over the streets in most of the world's great cities and their inhabitants would rise the next morning to find their houses cold and nearly all their factory wheels motionless. Nearly all of the world's locomotives would come to a dead stop, and about half of the world's ocean shipping would be left derelict. Production and transportation would be seriously crippled if not utterly paralyzed. The inhabitants of the great metropolitan centers of the world and of small countries such as Great Britain and Belgium would be the worst sufferers, for they depend absolutely upon the continuous delivery of

TABLE 5

ESTIMATED LIFE OF COAL RESERVES WITH DIFFERENT RATES OF INCREASE IN PRODUCTION (ANTHRACITE AND BITUMINOUS)

Country	Proved and probable reserves,* million metric tons	Average yearly coal production 1925–35 million metric tons	Probable life, years: With production constant at 1925–35 average	Probable life, years: With yearly increase of 0.5%	Probable life, years: With yearly increase of 2.0%
World	4,600,000	1,233.5	3,730	595	217
United States	1,975,000	535.8	3,686	593	217
Russia	1,075,000	30.3	35,478	1,037	330
Great Britain	200,000	230.3	868	329	147
Germany	289,000	148.1	1,951	470	186
Poland	138,000	37.8	3,651	590	216
Canada	286,000	11.3	25,310	969	314
China	220,000	16.5	13,330	842	282

* Data include only bituminous and anthracite coal to a depth of 2,000 meters (6,560 feet).

Source: Institut für Konjunkturforschung, *Energiequellen der Welt*, Berlin, 1937, p. 47, cited in International Labour Office, *The World Coal-Mining Industry*, vol. 1, League of Nations, Geneva, 1938, p. 40.

[8] *Ibid.*, pp. 57, 58.

[9] Estimate by R. Buckminster Fuller in "U. S. Industrialization," *Fortune*, vol. 21, February, 1940, p. 163.

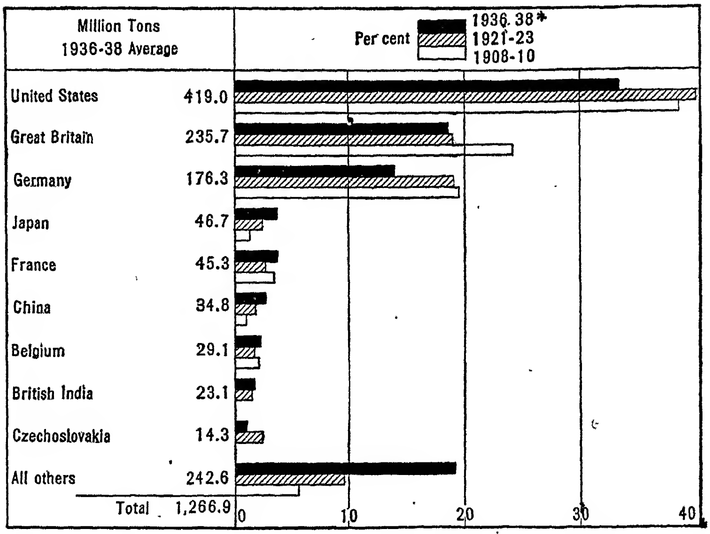
most of the things that they eat, wear, and use. Even if the world could suddenly use every drop of water power and every barrel of its petroleum reserves, catastrophe could not be averted. Millions of people would starve, and the survivors would be reduced to a much lower standard of living.

2. *British Coal Production and Trade*

Early Use. While it is generally believed that coal was dug up and burned as fuel by the ancient Britons before the Roman conquest, it is definitely known that during the thirteenth century coal was commonly used in manufacturing in Great Britain by brewers and smiths and that substantial shipments were carried by sailing vessels from Newcastle to London, where part was consumed in the city and part was reshipped to the continent.[10] In those early days coal mines were generally shallow holes in the ground which rapidly filled with water and were usually abandoned after a short period of use. The first great impetus to British coal mining came in 1709 with the discovery of a practical method of using coal in the smelting and manufacture of iron, a development that liberated forges and foundries from dependence upon the waning supply of wood and charcoal. Thus, Great Britain was already a user of coal before the steam engine was invented. The perfection of the steam engine proved to be a second and tremendous stimulus to the coal industry, for it was then possible to pump water out of the mines and to increase their depth, thereby increasing the supply of coal; furthermore, the steam engine together with other inventions in time led to a great increase in the demand for coal.

Great Britain was particularly fortunate in having coal ~~fields~~ near the sea and near to iron, which is necessary ~~for the harnessing of power derived from coal.~~ England had, in addition to power, an adequate labor supply, a stable government, and peace. With these advantages the modern factory system quickly originated. It came after a number of mechanical inventions in the latter part of the eighteenth century made it possible to assemble many workers in one building where their machines could be run by a common engine. Previously, the English manufacturing had been done by hand machines in the cottages of people who lived in populous country districts and tilled some land. But coal and steam made easy the establishment of the factory system, and condensed these people into cities often to their physical injury, changed Britain from an agricultural to a manufacturing country, and transferred the center of population and power from the agricultural southeastern plains to the rougher, more mountainous north-northwest and west with their coal and iron. Here people live in cities and get almost all agricultural products by trading, and the many manufacturing cities that have been developed give England a higher proportion of city population than any other country in the world.

[10] Isador Lubin, "Coal Industry," *Encyclopaedia of the Social Sciences,* vol. 3, The Macmillan Co., New York, 1930, p. 582.



*Japan 1934-36, China and British India 1935-37.

This graph of coal production, three-year average, shows interesting national changes reflecting the industrial depression of the 1930's and the improved technology of coal consumption. In 1936-38 Russia ranked fourth.

Leading British Coal Fields. The location of British coal fields favored this early development. The coal is good, although it is almost all bituminous, and the fields are well distributed, some on the east coast at Newcastle, some on the west coast in Cumberland, some in Scotland near Glasgow, some in Wales near Cardiff, and some inland near Sheffield and Birmingham and Manchester, making possible a varied development of industry. Each coal field has developed an industrial district. The southern inland coal fields support the great iron and steel manufactories of Sheffield and Birmingham, the northern give power for the cotton mills of Manchester and the other towns of Lancashire and the wool manufactures of Bradford, Leeds and Huddersfield in Yorkshire. The Cumberland field in northwest England has a steel center at Barrow-in-Furness, and the fields of southwest Scotland make Glasgow a great port and steel center and the Clyde a great shipbuilding river. The coals of Newcastle near good harbors have for seven centuries been carried in ships to London and across the North Sea to continental points, while the neighboring cities of Shields, Middlesbrough and Sunderland have in modern times become great shipbuilding and steel-manufacturing centers. The southwestern fields in Wales have led to a great smelting industry and export of coal.

The British Coal Export Trade. While coal has been exported from Great Britain for 700 years or more, it was the development of the ocean steamship during the nineteenth century that gave rise to the great British coal trade of modern times. Steamships arriving in northwestern Europe gladly

filled their bunkers with the high grade steam coals of Cardiff and Newcastle. Many of these ships were tramp steamers bringing to Britain and nearby lands full cargoes of grain, timber, ores, and many other foodstuffs and raw materials. Since few bulky outbound cargoes were available, they gladly took on full cargoes of British coal destined for ports and coaling stations scattered throughout the world. These outbound coal cargoes meant profits for the owners of coal mines, the exporters of coal, and vessel owners; they also meant that lower freight rates were charged on faw materials and foodstuffs inbound to Great Britain and northwestern Europe, an advantage accruing to manufacturers and consumers in general. So extensive was the British coal trade in the late decades of the nineteenth century that there was scarcely a port in the world that was not served with British coal, excepting only the ports of eastern United States and some nearby Caribbean ports where American coal was sold. British coal exports increased steadily from 3.2 million tons in 1850 to 14.0 millions in 1875, 44.1 millions in 1900, and 73.4 millions in 1913.[11] Indeed, throughout this period British coal exports exceeded those of all other nations combined. Among the advantages that contributed to the predominance of Great Britain in the world's coal trade were the long experience of the British people in coal mining and exporting; the variety and high quality of British coals; the short rail haul from mine mouth to seaboard, averaging less than 25 miles; proximity to industrial northwestern Europe and the coal-barren Mediterranean area, the two greatest markets; ownership of the world's largest navy and merchant marine, the greatest consumers of bunker coal; political control of 40% of the world's coaling stations so strategically located that they supplied 80% of the bunker coal used by all the steamships in the world;[12] and financial control of many railroads and other coal consuming industries in the vast British Empire and in foreign lands.

Since World War I the British coal export trade has suffered a drastic decline, decreasing from an all-time peak of 79.5 million tons in 1923 to 61 millions in 1929 and to 36.9 millions in 1939. The causes of this decline are of a serious and permanent nature. As other countries began to produce and export coal, British coal decreased in one market after another. For example, scarcely a cargo of British coal is now shipped east of Suez because of keen competition from South African, Indian, Australian, and Japanese coal, and between World War I and World War II much less was sold in the big European markets because of growing competition from German, Polish, and Russian coal. As one country after another turned to the use of petroleum and water power wherever available, their imports of British coal declined or ceased entirely, as happened along the west coast of North and South America. Today over one-half of the world's ocean-going merchant tonnage is propelled by petroleum, as compared with less than 3% in 1913, which has

[11] In 1913, in addition to coal exported as cargo, 21 million tons of coal were delivered as bunker fuel in British ports to ships engaged in foreign trade.

[12] Robert E. Annin, *Ocean Shipping*, The Century Co., New York, 1920, p. 90.

resulted in a great decline for bunker coal.[13] The best steam-electric plants now generate a kilowatt-hour with less than a pound of coal as compared with 3⅓ pounds in 1918 and 5 pounds in 1900, and such improvements in fuel economy have reduced the demand for coal per unit of power output. And in Great Britain increasing costs with increasing depth of coal mining, inability to mechanize production methods because of faulted seams, and a long standing resistance of labor unions to wage reductions have combined to increase the cost and selling price per ton. As a consequence, every important foreign market now consumes much less British coal than before World War I, and the British coal industry is confronted with a very serious problem. By exporting coal under any circumstances Britain has been selling the foundation stones of the house in which she lives.

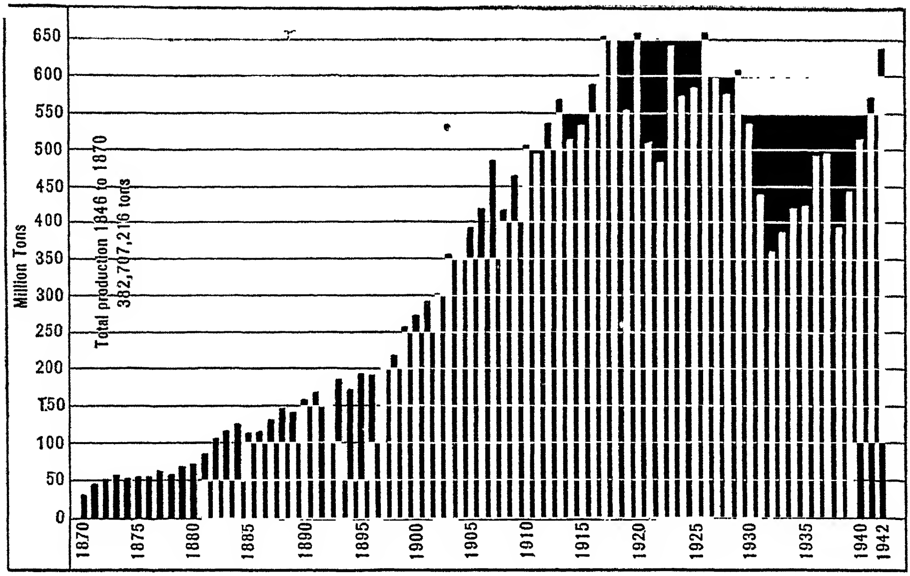
3. *The American Coal Industry*

Late and Rapid Development of American Coal Mining. During the first two-thirds of the nineteenth century, while England was busy manufacturing with coal, the people of the United States were chiefly employed in farming and settling the free lands of the Mississippi Valley which the United States Government was giving away to settlers, who rarely needed coal for the family stove. Our manufacturing industries started, before the improvement of the steam engine, in New England, where many streams tumbling down from the highlands made abundant waterfalls and good water power, as evidenced in the names of old New England mill towns, such as Fall River, Chicopee Falls, Rumford Falls, Bellows Falls, and many others. For domestic fuel the American people for two centuries burned wood, while England, old and relatively populous, had been short of forests in Queen Elizabeth's time and was using coal. In 1660 the British consumption was two-fifths of a ton per capita, a quantity not equaled in the United States until after 1850.

In 1793 the output of coal in the United States was about 63,000 tons, two-thirds of which was produced in Pennsylvania and one-third in Virginia. Production of Pennsylvania anthracite was probably only 200 tons.

A small coal field near Richmond, Virginia, was but a few miles from tide water at that city and because of that fact was, in the days before railroads and canals, the most accessible to eastern markets, because it could be carried to them over the natural waterways. The northward movement of the coal began in 1789, and this trade was used as an argument for the building of the Chesapeake-Delaware canal. This Richmond coal field, now entirely abandoned because of the competition of its superiors, was yielding 54,000 tons a year in 1822, while the Pennsylvania anthracite had reached a production of a ton a day by 1820. The Pennsylvania anthracite deposits served as a magnet to attract the pioneers at both canal and railroad building, a highway of each type being built up the Schuylkill River from Phil-

[13] In 1939 the sale of bunker coal in British ports to ships engaged in foreign trade amounted to only about 10,000,000 tons.

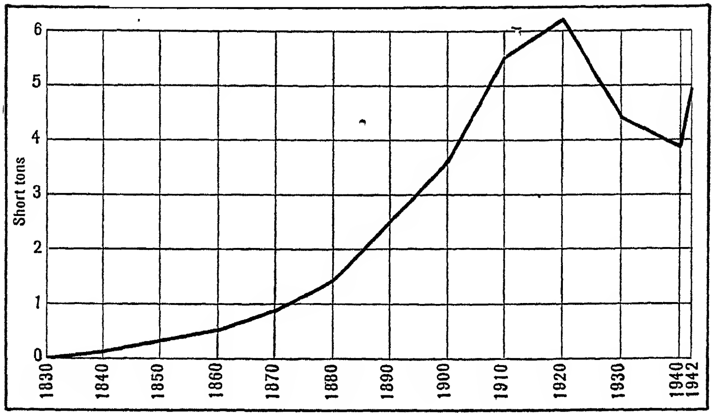


Is there anything that shows the industrialization of the United States more effectively than this graph of coal production? Wars send it up, depressions send it down. It would have been higher in later years but for the great improvements in coal consumption whereby one pound of coal does more work in power plants and other large units than it did in bygone years.

adelphia to the southern edge of the coal fields. By 1840, when the first census of coal output was taken by the federal government, the nation's total production of coal had increased to 2,070,000 tons.[14]

The Influence of Coal on Settlement of America. It was coal and steam that enabled the American people to finish the conquest of the American continent. In the two centuries between the founding of Jamestown and the marketing of coal in Pennsylvania, the colonists had slowly struggled westward through the forests and mountains and settled the river districts of western Pennsylvania, Kentucky, and Ohio, but the conditions of transportation in the west were such that no populous commonwealth could arise. Exports of grain and meat and a little lumber went to New Orleans down the Ohio and Mississippi Rivers in flatboats which were knocked to pieces because they could not be pushed upstream against the swift current. Imports were brought in wagons over the Allegheny Mountains to Pittsburgh and thence downstream to points where they were consumed. Economic and social progress was difficult under such conditions. In 1812 the steamboat changed all this by ascending the Mississippi River and making a two-way commerce. It enabled American people emigrating by the power of steam to attack the heart of the continent in a hundred places on the great navigable system of the Mississippi between Pittsburgh, Kansas City, Minneapolis, and upstream points on many smaller riv-

[14] National Resources Committee, *op. cit.*, p. 43.



This graph of coal consumption per capita in the United States gives us a chance to measure the poverty of Italy and other countries devoid of coal and with low purchasing power with which to buy it.

ers. Two decades later the steam-driven locomotive broke the shackles that had for ages held civilized man by the river bank and seashore, so that in half a century the American people spread five times as far as they had in the two preceding centuries.

Through the use of the steam engine coal not only hoists itself to the surface of the earth but hauls itself to market. It was the rapid development of our railroads during the latter half of the nineteenth century, together with the use of steam navigation on our coastal and inland waterways, that made possible the economical and large-scale transportation of coal. As Figure 75 indicates, the per capita production of coal increased from about one-seventh of a ton in 1840 to 3.5 tons in 1900, and to 6.2 tons in 1920. In 1918 the nation's output reached its all-time peak, a total of 678,212,000 tons, averaging 6½ tons for every man, woman, and child in the country. Since then the output per capita has declined, amounting to 3.8 tons in 1940 and nearly 5 tons during the war year of 1942.

Principal American Coal Fields. The first coal field to be extensively developed in response to the steam demand was the anthracite field of eastern Pennsylvania, which has the best coal in America and is also nearest to the cities of the Atlantic seaboard. The canal built up the Schuylkill from Philadelphia to this field was followed by some of the earliest railroads in America. Every railroad system anywhere near the district has reached out for a share of the coal freight until now a dozen railroads carry this coal in all directions, to Philadelphia, New York, and New England, on the east, to the Great Lakes on the north, and to the west, and the south. In 1940 about 90% of all anthracite was sold in New York, Pennsylvania, New Jersey, and the New England states; west of Pennsylvania, anthracite becomes somewhat of a luxury. The United States has a production of only four-tenths of a ton of this valuable coal

per capita per year, all produced in the small coal region of eastern Pennsylvania. The scattering remnants of a deposit once of much greater area are divided among the Lehigh, Schuylkill, and Wyoming fields with an outlying semianthracite field in the Bernice Basin of Sullivan County; these fields cover an area of only 480 square miles with the cities of Scranton, Wilkes-Barre, Pottsville, and Shamokin as the chief mining centers.

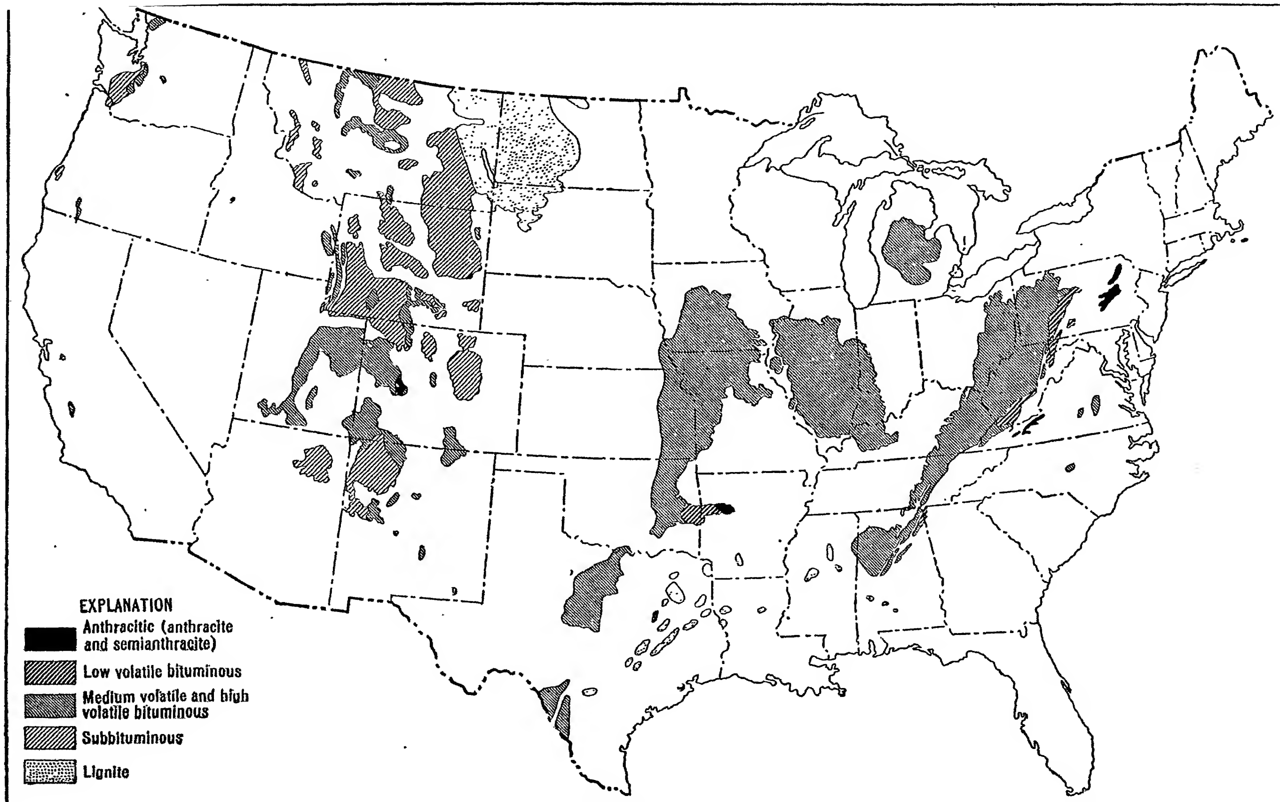
While the output of anthracite was about the same as that of bituminous coal in 1870, from that time on the relative importance of anthracite declined. By 1900 the tonnage of bituminous coal was four times that of anthracite, and in 1940 the ratio was 9 to 1. From a peak production of 89 million tons in 1917, the output of anthracite declined to 51½ million tons in 1940.[15] It is estimated that about 30% of our anthracite supply already has been mined or lost, whereas only about 2% of our bituminous and less than 1/10% of our subbituminous and lignite coals are gone. What is happening is that we are starting with the high ranks of coal and working down, skimming the cream of our natural resources as we have always done!

The improvements in methods of burning small sizes of anthracite coal have caused the closer utilization of the output and led to the re-working of the culm banks left by the mining operators of past decades. These reclaiming plants, called washeries, sent 2.9 million tons of coal to the markets in 1940.

The Appalachian coal field, reaching almost without a break from northern Pennsylvania into northern Alabama, contains the finest bituminous coal lands in the world. The coal area in western Pennsylvania alone is larger than Massachusetts, Rhode Island, and Delaware combined. Ohio River navigation opened this rich fuel deposit to the world and caused many new towns to spring up in the wilderness to shelter the miners. Pittsburgh, the so-called smoky city, standing where the navigable Ohio was formed by two navigable branches, was the most convenient point of access to this coal field and the natural place for its earliest development. Each year acres and acres of barges of Pennsylvania coal float down the Allegheny, the Monongahela, the Ohio, and the Mississippi, carrying millions of tons to Pittsburgh, Cincinnati, New Orleans and other cities along the great waterway.

The central part of this Appalachian coal field in West Virginia, eastern Kentucky, Tennessee and part of Virginia was not developed so early because it was more difficult of access, but many mines were opened there in the decade after 1915. At the present time there are in eastern Kentucky 10,000 square miles of this Allegheny plateau underlaid with coal. But this plateau has been carved by its many streams into a succession of steep mountains and sharp gorges which are so difficult to travel that in much of it there is no railroad, and therefore no commercial coal mining. The people of some localities thus isolated are living the life of the pioneers

[15] In addition, it is estimated that more than 4,000,000 tons of illicit or "bootleg" coal were mined in 1940. This practice began during the depression years of the nineteen-thirties, when unemployed miners started to mine, use, and sell coal belonging to the anthracite companies.—U. S. Dept. of Interior, *Minerals Yearbook, Review of 1940*, Washington, 1941, p. 824.



This map goes far to explain the industrial riches of the United States and one of the reasons why we won World War II. The Germans and Japanese knew we had few supplies and thought we couldn't make them quick enough to win, but the coal and our oil helped us to slip through.

TABLE 6

SUPPLY OF ENERGY FROM MINERAL FUELS AND WATER POWER IN THE UNITED STATES, 1871–1940

NOTE. *The figures, except coal equivalent, represent the equivalent of the heating power of the classes of fuel in trillions of British thermal units.* Data represent production, except those for oil imports, and take no account of exports, imports, or changes in stocks.

Annual average or year	Anthracite	Bituminous	Total coal	Domestic oil	Natural gas	Imported oil	Water power *	Grand total fuels and water power	Equivalent in bituminous coal †	
									Million tons of 2,000 lbs.	Per capita, tons
1871–75	637	754	1,391	49	...	...	*	1,520	58	1.4
1876–80	718	955	1,673	101	...	...	*	1,857	71	1.5
1881–85	985	1,863	2,848	153	24‡	...	*	3,110	119	2.2
1886–90	1,195	2,474	3,669	198	264‡	...	*	4,221	161	2.7
1891–95	1,453	3,286	4,739	307	166‡	...	104	5,316	203	3.0
1896–1900	1,513	4,493	6,006	357	198‡	...	129	6,690	255	3.5
1901–05	1,818	7,140	8,958	612	323	...	209	10,102	386	4.8
1906–10	2,207	9,783	11,990	1,037	470	1	369	13,867	529	5.9
1911–15	2,427	11,527	13,954	1,486	619	72	591	16,722	638	6.6
1916–20	2,523	13,981	16,504	2,176	820	297	851	20,648	788	7.6
1921–25	2,112	12,610	14,722	3,888	1,024	569	1,105	21,308	813	7.3
1926–30	2,084	13,595	15,679	5,375	1,760	408	1,781	25,002	954	8.0
1931–35	1,460	9,207	10,667	5,336	1,824	230	1,931	19,988	763	6.1
1933	1,348	8,741	10,089	5,434	1,672	191	1,931	19,317	737	5.9
1934	1,555	9,415	10,970	5,448	1,904	213	1,896	20,431	780	6.2
1935	1,419	9,756	11,175	5,980	2,060	193	2,207	21,615	825	6.5
1936	1,485	11,504	12,989	6,598	2,330	194	2,256	24,367	930	7.3
1937	1,410	11,673	13,083	7,675	2,588	165	2,446	25,957	991	7.7
1938	1,255	9,132	10,387	7,286	2,468	158	2,466	22,765	869	6.7
1939	1,400	10,345	11,745	7,590	2,663	199	2,423	24,620	940	7.2
1940	1,400	12,072	13,472	8,119	2,860	256	2,620	27,327	1,043	7.9
1941 (preliminary)	1,533	13,471	15,004	8,413	3,024	?	2,804	29,245	1,116	8.4
1942 (preliminary)	1,631	15,196	16,827	8,313	3,171	?	3,474	31,785	1,213	9.1

* Fuel equivalent is calculated from kilowatt-hours of power produced wherever available, as is true of all public-utility plants since 1919. Otherwise fuel equivalent is calculated from reported horsepower of installed waterwheels. Prior to 1890 data were unsatisfactory, but estimates are included in total.

† Calculated at 26,200,000 British thermal units per ton.

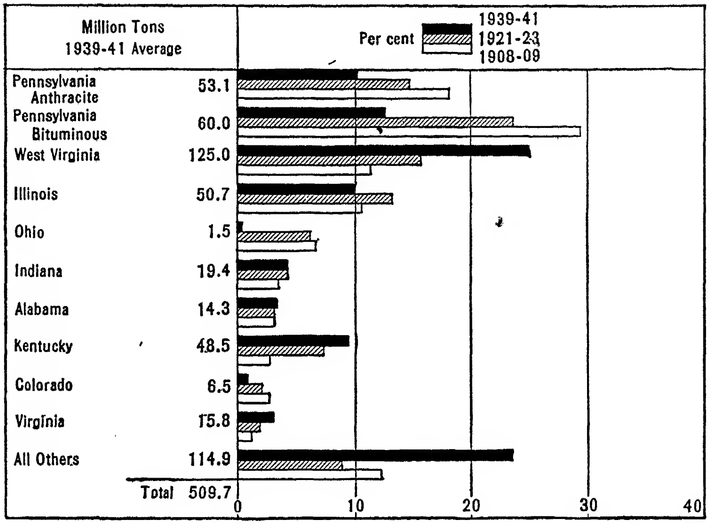
‡ Based on amount of coal displaced by gas, as estimated by gas companies.

Source: U. S. Dept. of Commerce, *Statistical Abstract of the United States, 1943*, Washington, 1944, p. 425.

and backwoodsmen of the Revolutionary period.

No more striking illustration of the dependence of economic welfare upon transportation facilities can well be found than the contrast between the poverty and ignorance of these isolated mountain people and the prosperity and commerce of their kinsmen and neighbors upon the lowlands beyond the mountains.

West Virginia, not so inaccessible as



Coal production by states. The industry is moving and spreading. Note the rank of Pennsylvania, West Virginia and Kentucky and the proportion in the unnamed states.

eastern Kentucky, but far less accessible than the Pittsburgh district, has become the greatest producer of bituminous coal. The West Virginia coal fields are difficult for railroads to cross and the valleys are so narrow that the houses of the mining towns are perched row after row upon the steep slopes that rise directly from the streams.

The southernmost of these eastern coal fields is in Alabama near Birmingham. It is very accessible to adjacent markets and hence has greater development than any field south of Kentucky. The building of locks and dams in the Warrior River, which permits the carriage of this coal in boats to Mobile and New Orleans for the supply of steamships and for export to Gulf and Caribbean ports, helped to increase the opportunity of this district for profitable development.

Appalachian bituminous coal is remarkably cheap. In 1940 the average price of locomotive coal at the mines was only $1.88 per ton, the average value at seaboard of bituminous coal shipped as cargo to foreign countries was $3.69, the average cost of coking coal at by-product coke ovens was $4.40, the average cost of high-grade bunker coal delivered to steamships engaged in foreign trade was $4.81, and the average retail price of bituminous coal in 38 cities was $8.60 per ton. The average rail haul for bituminous coal in the United States is about 155 miles, which more than doubles the cost of the coal by the time it reaches the market. High railway rates for short hauls have led to a great increase in the use of motor trucks for delivering coal up to 100 miles and more. Wherever possible, coal is shipped by water, some 25 million tons originating at river mines are shipped by barge directly to destina-

tion.[16] In 1940 about 47 million tons of bituminous coal were delivered to vessels at Lake Erie ports, and 35 million tons moved to Atlantic ports, chiefly Hampton Roads and Baltimore. Of 17 million tons of bituminous coal destined for New England in 1940, 12 millions were moved cheaply by coastwise vessels.[17]

The eastern interior field, southern Illinois, southern Indiana and western Kentucky, is second in importance only to that at the headwaters of the Ohio. The coal, bituminous, is not of as good quality as that of the Appalachian fields, but it is better than most of the coal of Europe and its nearness to Chicago, St. Louis and the manufacturing centers of Illinois and Indiana makes it the chief dependence of this region. Good coking coal is now mined in southern Illinois which is of great importance to the iron and steel plants at Gary and other midwestern cities. In 1940 the output of bituminous coal in Illinois, Indiana, and western Kentucky was about 77 million tons, or 17% of the nation's total bituminous output.[18]

It is an interesting fact that the quality of American coal declines as we go west until the Rocky Mountains are reached. The large western interior and southwestern fields extending from central Iowa to central Texas are inferior to those of Illinois and Indiana and are not so extensively mined. Beyond these the yet inferior coal that underlies vast areas of the plains of Dakota, Montana and Wyoming is mined only for local use. Most of it is lignite like the coal of Germany.

4. *Canadian, Alaskan, and Latin American Coal*

Canadian Coal Production and Imports. Canada, with large coal reserves, produced about 13.9 million tons of bituminous and subbituminous coal in 1940, or about half of the amount needed to meet her domestic requirements. The most populous and most highly industrialized parts of Canada in southern Ontario and the St. Lawrence Valley are without coal and hence must rely upon imported coal and local water power. In 1940 Canada imported about 13½ million tons of bituminous coal by rail and across the Great Lakes from the United States and the remainder from Great Britain. In Nova Scotia there is a coal field near the sea (and extending under it) and water transportation which enables it to be marketed in the St. Lawrence Valley as far west as Montreal and also in New England. Nova Scotian coal and Newfoundland iron ore meet at Sydney on Cape Breton Island, where iron and steel are manufactured.

The coal fields of Montana and the Rocky Mountain region are continued in Canada where parts of the western plain are underlaid by large deposits of coal, already of great service in driving the locomotives on the long railroads that connect the new wheat lands with the steamers on the Great Lakes. In the Canadian West are huge lignite fields, production amounting to 3.6 million tons in 1940.

British Columbia also has some coal in the immediate coast district which is

[16] Commodity Research Bureau, Inc., *Commodity Year Book*, Master Edition, New York, 1942, p. 87.

[17] U. S. Dept. of Interior, *op. cit.*, p. 770.

[18] *Ibid.*, p. 767.

used to some extent for bunkering ships at Vancouver.

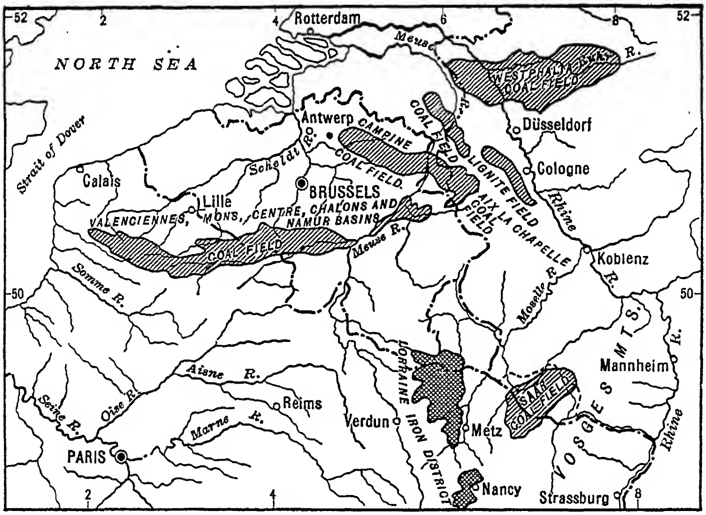
Alaskan Coal. Our incomplete knowledge of Alaska is being slowly extended,[19] and one of the surprises of this erstwhile little esteemed region is its valuable deposits of coal and copper. The coal veins are of astonishing thickness and are estimated to be worth millions of dollars. This source of supply, opened up by a government railroad and first extensively mined in 1918, now produces about 150,000 tons a year. While it is too inaccessible to be used rapidly, it is likely to prove a great boon to future generations.

The Limited Coal Resources of Latin America. In coal resources Latin America is singularly poor, and its entire output is less than a third of that of Canada. Indeed, if a steamship were to call for bunker coal at any Pacific port between Vancouver, British Columbia, and Valparaiso, Chile, it could not obtain a ton of coal that was produced locally. Chile leads all Latin American nations with an output of about 2 million tons of low-grade bituminous coal, which is mined at Lota and Coronel along the seacoast. Brazil is making every effort to develop her meager deposits so that she can utilize her vast iron ore reserves for steel manufacture. Most of the output of less than 1½ million tons is mined at São Jerônimo in Rio Grande do Sul and near Tubarão in Santa Catarina and is shipped to Rio de Janeiro for the manufacture of power and gas. In Mexico about 500,000 tons of fairly good bituminous coal are produced annually near Sabinas and Lampazos in northern Coahuilla, most of it being shipped to the iron and steel center of Monterrey. The Colombian output of only 300,000 tons is mined near Medellín and Bogotá, where it is used by small manufacturing enterprises. Peru mines about 100,000 tons for use in her mining industry, and in coal-destitute Bolivia some of the copper companies burn *taquia,* or dried llama dung, rather than pay $40 a ton for imported coal.

5. *Coal in Europe*

German Coal Production and Exports. The remarkable industrial development of Germany within the last 70 years has been accompanied by an extensive exploitation of coal deposits. As a consequence, German bituminous coal production increased from 29 million tons in 1871 to 109 millions in 1900, and to 200 millions in 1939. Germany is fortunate in having the greatest coal deposit in continental Europe, the Westphalian field of western Germany which contains about 90% of German coal reserves and which produces about three-fourths of the annual output. The seams of this field vary from 5 to 30 feet in thickness and yield high-grade coking, steaming, and gas coals. Within this field is the famous Ruhr Valley, with its heavy industry and about 70% of the nation's coal output, which was a special target for Allied bombers during World War II. Although most of the Silesian field of eastern Germany was

[19] One estimate credits Alaska with probable coal reserves of 3.6 billion metric tons and probable lignite reserves of 16.6 billion metric tons.—International Labour Office, *op. cit.*, p. 39. Since less than half of Alaska has been surveyed topographically or geologically, even on reconnaissance standards, there is no dependable information regarding mineral deposits in an area of about 300,000 square miles.—National Resources Committee, *Regional Planning, Part VII—Alaska,* Washington, December, 1937, pp. 78-79.



This map of the coal fields of France, Belgium, the Netherlands, the lower Rhine and the Saar shows that France, Belgium and Germany share one coal field. Its location, close to the sea and the navigable Rhine, is very favorable for industrial development. The Lorraine ore district, so close at hand, completes the basis for great industrial power. It is said that Bismarck sent geologists in 1871 to fix the German boundary so that it included this ore field—basis of power.

given to Poland as a result of the Treaty of Versailles following World War I, the portion of this field left to Germany contributed about 17% of the German coal output in the years preceding World War II.[20]

Other coal mining areas in Germany are those of the Saar Basin, Aachen, and Saxony. Germany is not only the third largest producer of bituminous coal, but throughout the present century she has usually ranked second only to Great Britain in the volume of exports, which in prewar years amounted to about 25 or 30 million tons annually, about three-fourths of which moved by rail or inland waterway to Italy, France, Holland, Belgium, and Switzerland. Since World War I her seaborne exports to South American, Mediterranean, and Baltic countries have increased. Germany leads the world in the production of lignite with an output of 230 million tons in 1939. Nearly half of the lignite is mined in central Germany, chiefly in Saxony, the remainder being produced in the Cologne district of the Rhineland and also east of the Elbe River.[21] No other country has approached Germany in the use of lignite in electrical, chemical, and other industries, which have been developed in the mining areas.

The Coal Fields of Russia. During the decade that preceded World War II no country equaled the remarkable industrial expansion achieved by Russia. In this brief span of time the Russian government made great efforts to develop manufacturing and mining industries. Between 1928 and 1938 the output

[20] International Labour Office, *op. cit.*, p. 59.

[21] *Ibid.*

of coal and lignite increased from 25 to 133 million tons, about three-fourths of which was bituminous coal. Furthermore, Russia now has an output of anthracite coal of about 35 million tons annually, second only in volume to the United States.[22] In spite of Russia's wealth of firewood, peat, petroleum, and water power, coal furnished well over 70% of the energy requirements of the nation in 1937. By far the most important coal producing area is the Donetz Basin, which usually mines more than two-thirds of the nation's coal. Other important fields are the Kuznetz Basin in Siberia, the Toula field near Moscow, the Karaganda field of Turkestan, and several fields in the Ural Mountains. The coal fields of Asiatic Russia, which provided about a fourth of the total output of bituminous and lignite coal in 1938, will undoubtedly be developed far more extensively in the future.

French and Polish Coal Industries. The fact that France must import about a third of her coal supply from Great Britain and Germany reveals her greatest industrial handicap. About two-thirds of the French output of nearly 50 million tons is mined in the Sambre-Meuse field in the provinces of Pas-de-Calais and Nord, this field extending across southern and eastern Belgium into Germany near Aachen, with a small spur appearing in the southern tip of Holland. This field is not only the backbone of the French coal industry, but it makes Belgium and Holland virtually self-sufficient in coal. While the coal of this field is good for making steam, heat, and gas, it must be mixed with higher grade imported coals in order to manufacture coke. About one-eighth of French coal is mined in Alsace-Lorraine, the remainder being produced in scattered localities of central and western France. Both French and Belgian coal mines have been operated for a long time, and there is little prospect of any substantial increase in their output.

Poland, with an output of 38 million tons in 1938, is the only other important coal producer in Europe. About three-fourths of Polish coal is mined in eastern Upper Silesia, and most of the remainder, in the Dombrova Basin. About a third of the nation's output is exported to the coal-poor countries along the Baltic Sea.

6. *The Coals of Asia, Australia, and South Africa*

Japanese Coal. Coal mining in Japan is a long-established industry, certain beds having been worked for over 400 years. During the present century Japan has had the ambition to become a great industrial nation, the government has given large subsidies to every important industry, and every effort has been made to develop the nation's meager coal reserves. At the outbreak of World War I, Japan was mining 21 million tons of coal a year and exporting over 4 million tons. In 1936 41.8 million tons of coal were mined in Japan proper, on the islands of Kyushu and Hokkaido, which fulfilled 95.7% of the domestic demand.[23] In that year Japan exported about 1 million tons of coal and imported 2 million tons from Karafuto,

[22] *Ibid.*, p. 59.

[23] Kate L. Mitchell, *Industrialization of the Western Pacific*, Institute of Pacific Relations, New York, 1942, p. 25.

TABLE 7

World Coal Production and Reserves

(Millions of metric tons)

Country	Production in 1938		Estimated Reserves	
	Coal	Lignite	Coal	Lignite
North America:				
Canada	10	3	242,400	572,686
United States	355 §	3	2,036,759	852,278
Other countries	1	...	7,055	16,563
South America:				
Brazil	1	...	5,000	......
Colombia	...	...	27,000	......
Chile	2	...	200	25
Other countries	...	...	2,005	......
Europe:				
Belgium-Luxemburg	30	...	11,000	......
Czechoslovakia	14	13	28,000	12,000
France	47	1	10,000	500
Great Britain	231	...	174,501	......
Germany	186	195	289,000	56,758
Poland	38	...	61,781	5,000
Other countries *	25	21	20,313	15,818
U.S.S.R.	133 ‖	?	1,443,268	211,093
Asia:				
China †	37 ¶	...	244,093	2,826
India	29	...	20,600	2,600
Japan ‡	53	...	16,218	473
Other countries *	7	...	13,239	1,201
Africa:				
Union of South Africa	16	...	205,723	......
Other countries	2	...	10,742	12,756
Oceania:				
Australia	12	4	16,715	41,276
New Zealand	1	1	1,400	600
World total	1,230	241	4,887,002	1,804,453

* Excluding U.S.S.R.
† Including Manchuria.
‡ Including Korea and Formosa.
§ Includes 42,000,000 tons of anthracite.
‖ Includes lignite, possibly 10,000,000 to 15,000,000 tons.
¶ Data as of 1937.

Source: Production data compiled from *Statistical Year-Book of the League of Nations, 1940-41*, pp. 133-134. Reserve data obtained from various official sources.

Korea, and Manchuria, and about 2.2 million tons from other sources. Most Japanese coal is low-grade bituminous coal unsatisfactory for coking, and its high price and low quality have been an obstacle to the profitable development of the iron and steel industry. Under Japanese control, Korean deposits were developed intensively, resulting in an output of 4.5 million tons of good bituminous coal and 2 million tons of anthracite in 1939.

Chinese Production and Reserves. The largest coal reserves in all of Asia, and among the greatest in the world, are those of China which have been estimated at amounts varying between 220 and 997 billion tons.[24] This huge reserve has been scarcely touched by the Chinese, who have been farmers for more than 40 centuries. While nearly every province has some coal, nearly 90% of the apparent reserve is concentrated in the Loess Highlands of Shansi, Shensi, Honan, and Kansu, while Shansi province alone is estimated to contain some 36 billion tons of anthracite coal.[25] This region in northern China some day will undoubtedly become the seat of a great mining industry. Coal mining is concentrated in the hands of a few large operators, financed chiefly by foreign capital, and the bulk of the output of nearly 30 million tons[26] comes from mines located along railway lines or near water transportation. The railroads and steamships are large consumers of coal, and considerable amounts are sold in Shanghai, Peiping, Canton, Hankow, and other large cities. If manufacturing is developed in this part of the world, Chinese coal will play a stellar role.

India and French Indo-China. India has a reserve of coal estimated at 36 to 60 billion tons, of which 5 billion tons are of good quality and easily mined, including about 1.4 billion tons of coking coal.[27] Fully 90% of the annual output of less than 25 million tons is mined in the provinces of Bengal and Bihar and Orissa to the northwest and southwest of Calcutta. Most of the Indian coal is used by the railroads, textile mills, and the gradually expanding iron and steel industry.

French Indo-China was the largest producer of anthracite coal in the Orient in 1939, the annual output of 2½ million tons being about half that of Great Britain or Belgium. The mines in Upper Tonkin are exclusively controlled by French corporations, and about three-fourths of the output is exported, chiefly to Japan, China, and France.

Australasia and South Africa. Both Australia and New Zealand have enough coal for their own needs. Coal is found in all six states of Australia, but 90% of the output of 14 million tons is high-grade bituminous coal that is mined near Newcastle in New South Wales and is shipped by coastal steamer to Sydney and other urban markets in the southeastern part of the country.

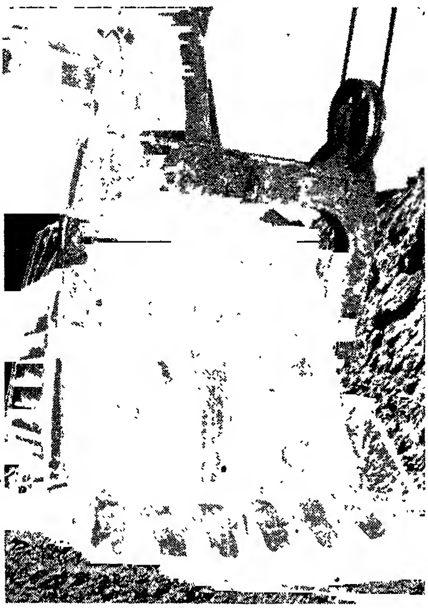
[24] For a German estimate of 220 billion tons as of 1937, see Table 5. In 1932 the Chinese geologists, W. H. Wong and T. F. Hou, estimated the probable reserves to be 246 billion tons, including at least 185.2 billion tons of bituminous and 45.5 billion tons of anthracite coal. In 1912 an American geologist estimated Chinese reserves to be 996.6 billion tons. For these and other estimates, see George B. Cressey, *China's Geographic Foundations*, McGraw-Hill Book Co., Inc., New York, 1934, p. 112.

[25] *Ibid.*, pp. 112-113.

[26] In 1936 China produced 27 million tons of coal, including the Manchurian output of 12 million tons.—U. S. Dept. of Commerce, *Foreign Commerce Yearbook, 1939*, Washington, 1942, p. 242.

[27] Kate L. Mitchell, *op. cit.*, p. 276.

The continent of Africa seems to be poor in coal, with the exception of South Africa where the Transvaal and Natal have a combined production of over 17 million tons annually. The Natal de-



Recent development of the steam shovel concept grown gigantic gives us one of our most spectacular and wasteful methods of mining coal. This so-called electric shovel strips the earth off of seams near the surface, swings it away and reclaims the coal 50 or 60 feet below the surface of the ground. Sometimes it begins with a fine prairie with good black soil ready for a thousand crops and gets one crop of coal and leaves a pile of rocks. You are free to do this.

posits consist of excellent steam coal, and Durban has become a bunker station and exporter of coal.

Africa shares the terrible past, from the coal standpoint, of all the hot lands. It has never been cool enough to let great masses of peat accumulate. The vegetation seems to have decayed rather than pile up as it now piles up in the muskegs and peat bogs of Canada and Europe.

7. *Methods of Mining Coal*

Principal Methods. There are two main methods of getting coal out of the earth, strip or open-pit mining and underground workings. In open-pit mining the overlying earth, or overburden, is first removed, and then the coal is excavated by pick and shovel or by power-driven machines. Open-pit mining, of course, can be practiced only where the coal lies relatively near the surface, yet about 11 to 13% of all anthracite and 7 to 9% of all bituminous coal in the United States is mined this way. Much of the coal of China and 85% of the lignite of Germany are minded by open-pit methods. In many parts of the Rocky Mountains and the Great Plains the coal outcrops are so abundant that the scanty population can be supplied by going to the cliffs, bluffs, or river banks and digging it down with the pick and shovel and hauling it away in the farm wagons.

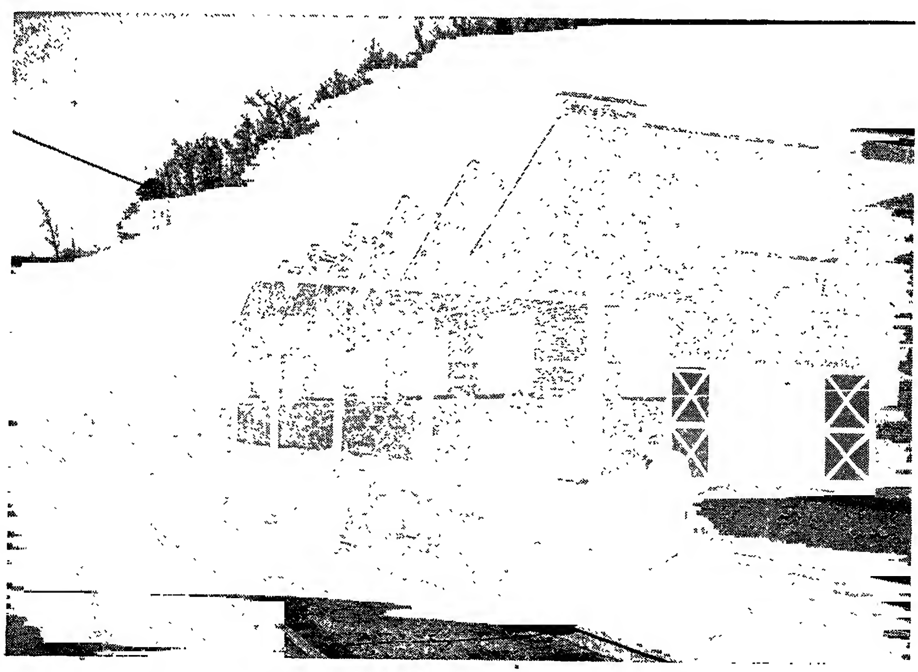
In the second method, underground workings, drift, slope, or shaft mining methods may be used.[28] In drift mines the coal seam outcrops on the hillside and lies nearly flat, and the coal can be taken out as the tunnel is dug forward into the seam. In slope or slant mines, the coal outcrops on the hillside but lies in an inclined bed, so a sloping tunnel must be built to mine the coal. If the coal bed lies deep under the surface with no convenient outcrop, then a vertical shaft must be sunk to reach the coal

[28] Two systems are generally used in working coal seams: the "room and pillar," which consists of main tunnel, lateral tunnels, and rooms beside these; and the "longwall" system in which the coal is removed from a continuously receding working surface.

seam. In our bituminous fields most shafts are only about 200 to 400 feet deep, while in Great Britain many shafts go down 2,000 feet, and some for 3,500 feet. In Germany the average depth of shafts is about 1,500 feet, the deepest being about 4,000 feet. Sometimes workings extend under the sea as along the coast of northeastern England, in Nova Scotia, and in Chile.

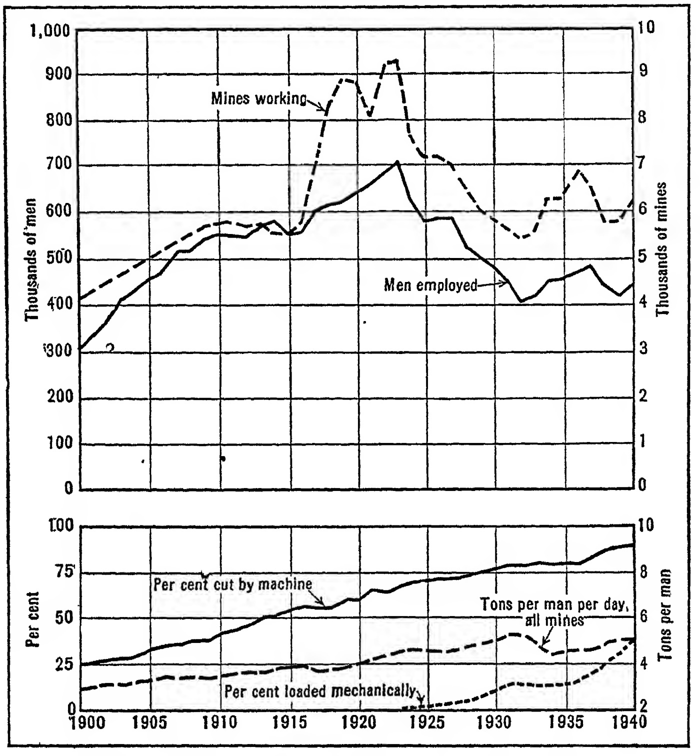
Pennsylvania anthracite lies in the folded and bent strata of mountains, the pressure of mountain-making having turned the coal to anthracite. It may outcrop in some places, as at Hazleton, so that it can be quarried from the surface. Nearby it is buried 3,000 feet in the ground, requiring deep shafts which go below the level of the sea and involve much moving of rock, pumping of water and lifting of coal. Then the anthracite requires much sorting, cleaning, and preparing to get it clear of the shale so that 5% of the coal is used in the mining, while in bituminous mining in the United States only 0.6% is so used.

Increased Use of Machinery. The United States has long led the world in the use of modern machinery in mining with the result that our output of coal per man per year greatly exceeds that of other nations. Largely as a consequence of increasing mechanization, the output of bituminous coal per man per year in this country has increased from 579 tons in 1890 to 1,049 tons in 1940. In our anthracite industry, because of folded and faulted coal seams, much more work must be done by hand, yet greater mechanization has helped to in-



A train of mine cars running out of an almost horizontal coal seam in Appalachia, the easiest and most satisfactory kind of coal mining in the world—and also some of the best coal.

crease the output per man per year from 369 tons in 1890 to 617 tons in 1940. It is estimated that in 1940 80.1% of our bituminous coal was mined by machines as compared with 3.3% of our anthracite. Every year more machines are used in our underground workings to cut coal, load it, transport it to the mine shaft, hoist it to the surface, and to help wash, break, and assort it and otherwise prepare it for the market. Wherever geological formations permit, European mines have likewise made great progress since World War I in the mechanization of mining and have greatly increased their output per man.[29]



Look carefully at these two graphs. The lower one shows what machinery is doing and helps to explain the great increase in tons per miner per day and our high per capita consumption. The upper graph would be much more effective if it showed the number of days' work per miner as well as the number of men. There was great unemployment in coal mining through much of this period. The lower graph gives one reason for this. Another reason—the mines were manned during World War I and people hate to move.

[29] According to one estimate, the output of coal in kilograms per man-shift in 1935 was: U. S. A. (bituminous) 4,080, Germany (Ruhr) 1,692, Great Britain 1,185, France 872, Belgium 775. It is also estimated that in 1935 the percentage of coal output obtained by machinery in underground workings was: U. S. A. (bituminous) 84%, Germany (Ruhr) 96%, Great Britain 51%, France (Pas-de-Calais) 88%, Belgium 98.5%. Our high output is obviously due to the thickness of our seams and other factors besides mechanization.—International Labour Office, *op. cit.*, pp. 106, 108.

8. The Utilization of Coal

The greatest uses of coal are for engines—factory, locomotive, or steamship—for the domestic fire, for the smelter that extracts metals from ores, for the coke ovens, for the electric power house and gas works. The railway locomotive is a tremendous user of coal—also a tremendous waster of it, since it is estimated that only half of the locomotive fuel is utilized for effective work.

In the ordinary methods of using coal as fuel in grates and furnaces much of the heat value of the coal goes off up the smokestack, unused, in the form of gas and smoke.

The process of briquetting enables the use, as fuel, of coal dust and fine fragments which would otherwise have to be discarded as mine refuse. Briquettes are compressed lumps of coal made by mixing small particles of coal with some adhesive material and pressing it in molds so that it holds its shape until burned. In Germany 44 million tons of briquettes were made in 1938, while the industry is only getting started in the United States after many years of trial. It should enable us to save millions of tons of coal now wasted. Its greatest promise may be in connection with coke. Coke breeze possesses high fuel efficiency, but because of its small size, cannot be used as such either for domestic or other fuel. The quantity of this coke breeze produced in the United States in 1940 by by-product coke ovens was about 4 million tons, most of which was used by the producers for raising steam.

Nevertheless, progress has been made in this country in the utilization of coal, as is shown by the fact that between 1920 and 1940 the consumption of coal per unit of output has been reduced 20% in pig-iron production, 34% in steam locomotives, and 56% in electric public utility power plants.[30]

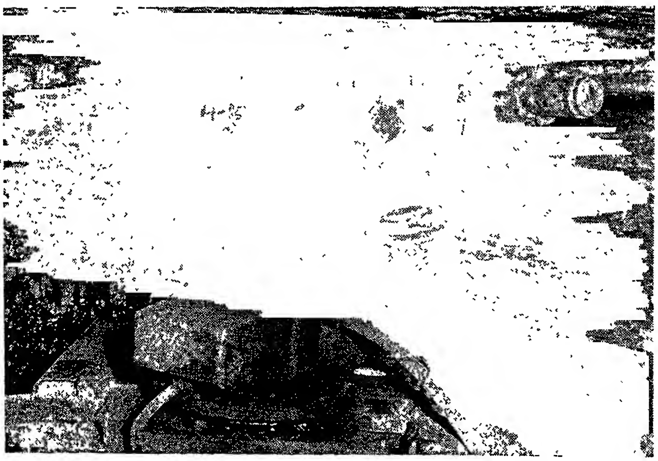
9. Coke and Its By-products

What Comes from Coal. Iron and steel making require the use of coke. Coke is made by heating coal in closed retorts, where the volatile matter is driven off as vapor and the coke is left in big lumps that are harder than the coal itself and therefore hold up the burden of the ore so that the fire in the blast furnace does not smother. By the old coke methods, the coal was roasted in simple "beehives" or conical kilns of brick, and the gas and liquids were burned or allowed to escape as undesirable refuse. The modern "by-product plants" for distilling coal are elaborate and expensive, but they quickly pay for themselves by converting this refuse matter into a great variety of useful and valuable products. From 2,000 pounds of bituminous coking coal are obtained 1,450 pounds of coke for use in the smelting of iron and other ores or for use as domestic or industrial fuel; 27 pounds of ammonium sulfate for the manufacture of fertilizers, explosives, and chemicals and for use in refrigeration; 12 gallons of coal tar for the production of a thousand analine dyes, pitch, flavoring extracts, perfumes, and many other things; and 11,500 cubic feet of gas for heating and lighting. The distillation of coal can also be made to

[30] Charles K. Leith, James W. Furness, and Cleona Lewis, *World Minerals and World Peace*, The Brookings Institution, Washington, 1943, p. 20.

A

The coal-mining machine runs on little railroad tracks and cuts under the bottom of the seam so that it is easy to bring it down with small charges of explosive. The props indicate a firm, solid, hard rock roof. Some mines leave a considerable proportion of the coal in the mine to support the roof.



B

Man drilling a hole in the top of a coal seam by electric power. This big heavy machine, like the other one, and the mine cars run through the mine on miniature railroad tracks.

yield automobile fuel, as has been done in Germany. We should be putting scores of millions of tons of soft coal through this process and getting dustless coke to burn instead of anthracite coal. England is doing it. Here again technique is ready; only conservatism blocks the way.

The Germans, scientific and thrifty, led the world before World War I in the manufacture of by-product coke, coal tar by-products, and gas engines. The by-product oven gained ground more slowly in America, but the increase has been steady except for the rush period of armament for World War II (see Table 8).

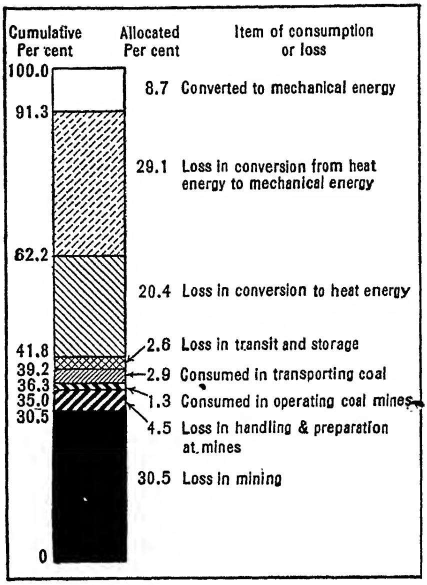
TABLE 8

COKE PRODUCTION IN THE UNITED STATES, 1900–40

(In millions of net tons)

Year	*By-product*	*Beehive*	*Total*	*By-product per cent of total production*
1900	1.1	19.4	20.5	5.2
1905	3.4	28.8	32.2	10.7
1910	7.1	34.6	41.7	17.1
1915	14.1	27.5	41.6	33.8
1920	30.8	20.5	51.3	60.0
1925	33.9	11.4	51.3	77.9
1930	45.2	2.8	48.0	94.2
1935	34.2	.9	35.1	97.4
1940	54.0	3.1	57.1	94.6

The Future. The fact that we are mining such huge quantities of coal, a wasting asset, is causing some concern for fear of the exhaustion of our coal resources at a much earlier time than we previously thought possible. The price of coal is rising and must continue to rise. This turns our attention again toward substitutes, of which the chief are water power and petroleum, now both in active competition with coal. Of



We have wonderful machinery, and power does marvels for us, but see how little of the heat energy we really get. Here's a great field for possible improvement—a challenge to the chemist and the engineer.

these, the oil may have an advantage of cheapness while it lasts, but all the minerals are at best an accumulation soon robbed and are but ephemeral in comparison to water power which, depending upon the sun, the sea, and the highlands, remains an enduring source of power while climate and land endure.

When coal is used, it is gone forever. As the National Resources Committee warns us, "In a sense the United States, and for that matter, the world, is 'stranded' with a limited supply of min-

eral fuels. No one knows when a rescue party in the form of better sources of energy may arrive. In the light of experiences thus far with substitute sources, encouraging signs have not been sighted. But the situation with regard to the total coal reserve is not precarious. If we are willing to make an increasing-cost sacrifice for coal mining, enough coal can be obtained to last for hundreds of years. What is important in the short run is the exhaustion of the best ranks of coal in the most readily minable beds near areas of large consumption."[31] Obviously, we must conserve and use our resources wisely in order to live. Will we ever think of ourselves as a *race* or a *civilization?*

[31] National Resources Committee, *Energy Resources and National Policy,* Washington, January, 1939, p. 84.

■ ■ ■ 5

Petroleum and Water Power: Fugitive and Permanent Fuels

1. The Importance and Use of Petroleum

Early Use. Petroleum is most commonly regarded as a source of fuel for the world's 50 million automobiles, but its use may be traced back to ancient times. Modern excavations on the sites of the old Babylonian and Assyrian Empires have disclosed fragments of bricks bound together with a petroleum asphalt base, and some 400 years before the time of Christ the Greek historian, Herodotus, described a trade in petroleum.[1] It is known that the ancient Chinese made use of petroleum for medicinal purposes, as did medieval Europeans and the North American Indians. In modern times, however, petroleum's first great use was to provide light for the world.

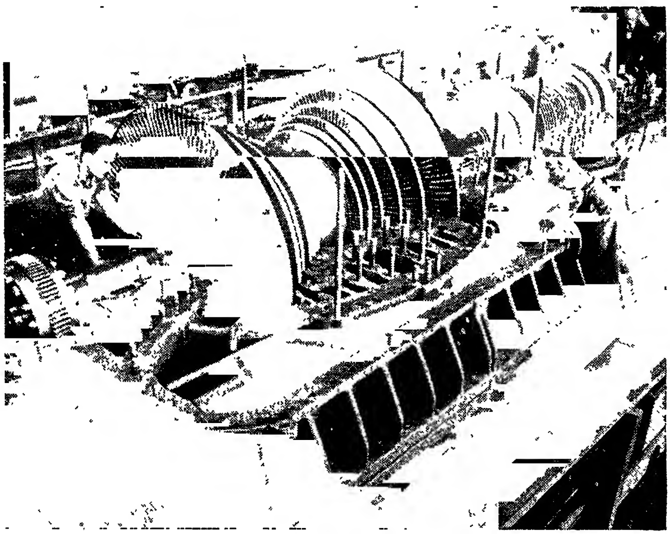
A Source of Light, Lubricants, and Power. For ages mankind had groped at night in the gloom of the tallow candle or in the smoky light of some primitive oil-burning lamp utilizing various vegetable and animal oils. The lamps of southern Europe burned olive oil, whereas those of northern Europe and America used whale oil. By the middle of the nineteenth century the demand for whale oil had become so great that the whales were well nigh exterminated. Hence, distillation plants for producing illuminating oil from oil shale and cannel coal increased rapidly during the 1850's in both England and America. As the demand for coal oil increased in this country, the attention of American capitalists was directed to the strange black stuff called "rock oil" that oozed from the ground and spread a scum on the surface of creeks in western Pennsylvania. In 1857 was organized the Pennsylvania Rock Oil Company, which sent one of its employees, Edwin Laurentine Drake, a former railway conductor, to investigate the company's landholdings along Oil Creek near Titusville, Pa., where he was introduced to the community as "Colonel" Drake. Two years later Drake set up a crude derrick, and, after three months of persistent drilling to a depth of 69 feet, struck oil on August 27, 1859. "Drake's Folly," as it had been dubbed by scoffers, yielded 2,000 barrels of crude petroleum by the end of the year. Prospectors, diggers, swindlers, and other fortune hunters swarmed into the area and drilled furiously for oil, and America's first oil boom was under way. Little refineries were set up to obtain the prized kerosene, gasoline being burned

[1] George W. Stocking, "Oil Industry," *Encyclopaedia of the Social Sciences*, vol. 11, The Macmillan Co., New York, 1933, pp. 438-439.

or thrown away. Oil flowed faster than barrels could be made to hold it, and between January 1, 1860, and January 1, 1862, the price of crude oil at the well dropped from $20 to 10 cents a barrel, the petroleum industry being confronted with its first overproduction problem.[2]

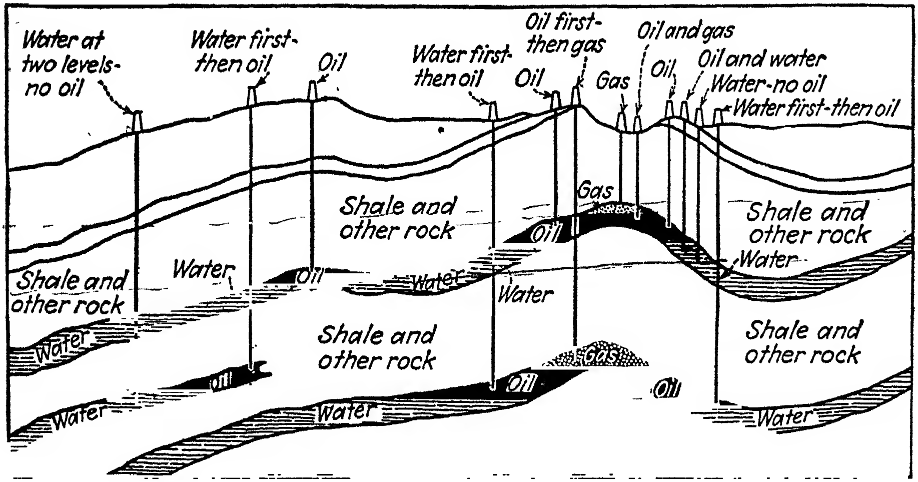
Kerosene—or "coal oil," as it was erroneously called by most consumers—proved to be much cheaper than whale oil. The kerosene lamp invaded the homes of every continent, and for well over half a century it was the world's chief source of light. Indeed, kerosene still provides light for millions of homes throughout the world as well as serving as domestic fuel for cooking and heating.

While hundreds of products are derived from petroleum today, none render a greater service to mankind than the oils and greases that are used to lubricate the countless moving parts of modern machinery. High-speed machines require careful lubrication to reduce friction to a minimum, and there is no good substitute for petroleum as a lubricant. Without petroleum, our proud Machine Age would grind ignominiously to a dead stop.



A steam turbine. This huge shaft, visible at the left, extending the whole diagonal length of the picture, is the backbone of the moving part of the steam turbine. The upper half, for which the restraining bolts can be seen, has not yet been put in place. Look closely and you can see the numerous arms or rays which the steam strikes, one after the other, as it passes from the right end to the left end of the whole turbine. Under high pressure at the right, the steam has small volume. As pressure decreases, the volume increases, and the length of the rays and the diameter of the turbine must increase to give space for the passage of the increased volume of steam. This type of engine can attain great speed and therefore has a small size per unit of output.

[2] Production increased from 500,000 barrels in 1860 to 2,114,000 barrels in 1861 and to 3,057,000 barrels in 1862.



This cross section shows how much of a gamble oil drilling may be unless someone really knows the local geology. Oil geology has made great advance of late.

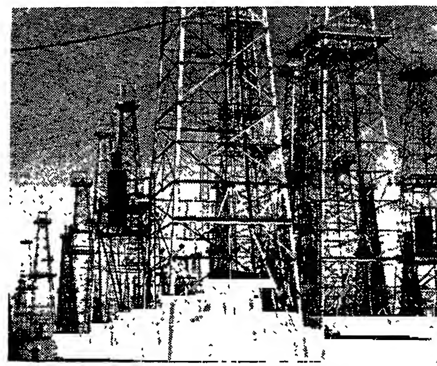
pressure of ground water beneath forcing the oil and gas upward into the pocket. Hence, the world's great petroleum deposits are found in plains or plateau areas where the nearly horizontal rock strata have not been disturbed by excessive folding or faulting of the earth's crust, which would have ruined the natural oil pockets by cracking their impervious covers.

A Fugitive Resource. Because of its hidden and uncertain location beneath the surface of the earth, because of its peculiar structural formation, and because of its liquid and gaseous nature, petroleum is one of the most elusive of all the resources that are used by man. From the very beginning, the petroleum industry has been confronted with uncertainty. Always there is the perplexing uncertainty about the size of petroleum reserves, and for years the industry has been torn between the dire warnings of the pessimists who claim that the petroleum supply will not last longer than a decade or two and the rosy predictions of the optimists who assert that the supply will last for a century or two.[6] The fact is that the best geological estimates are merely educated guesses, that every estimate to date has been subsequently proved wrong, and that we simply do not know how much petroleum remains in the ground in the United States or any other country. Secondly, there is the uncertainty in locating petroleum deposits. For a long time prospecting was entirely a matter of random drilling, or hit-or-miss methods known as "wildcatting." Today skilled geological and geophysical crews use such modern equipment as the seismograph, the torsion balance, the magnetometer, the electrical log, and the aerial camera to

[6] According to reports of the Committee on Petroleum Reserves of the American Petroleum Institute, the United States had on January 1, 1941, proved reserves amounting to 19 billion barrels, or a supply adequate to last for about 13 years.—U. S. Dept. of Interior, *Minerals Yearbook, Review of 1940*, Washington, 1941, p. 938.

determine the possible location of oil,[7] yet, in spite of all the advancements of science, there is no sure formula for discovering oil.

Thirdly, there is the uncertainty involved in competitive drilling, together with a tremendous amount of waste. It is perfectly legal for your neighbor to drill a well and to drain out the oil from under your land, and your only recourse is to drill as promptly as he does. Hence, as soon as oil is discovered in a given locality, everyone drills for oil, and the terrain is soon transformed into a veritable forest of derricks and (perhaps) gurgitating gushers. Far more wells are put down than are necessary, and the gas on top of the oil usually escapes, and its pressure is lost. This might well have been used to help force petroleum out of the ground. Because of this folly, much petroleum remains underground that can not be recovered except by expensive pumping. In the mad scramble for oil, the landowner is certain only of the oil that he can actually get from under his land. Fourthly, there is the uncertainty of the volume and length of the yield. An oil well may gush forth its wealth for decades, or the dreaded salt water may appear after a few years or months, indicating the end of the oil supply. Hence, production has been characterized by alternating feasts and famines, together with great changes in the price of petroleum. And, fifthly, there is the uncertainty of financial return to the investors, all of whom seem to think that they will strike it rich. The gamble of drilling for oil has such a powerful speculative appeal to the investing public that there seems to be no end to the amount of capital available for drilling, which in itself is a powerful force contributing to overproduction and general instability.[8]

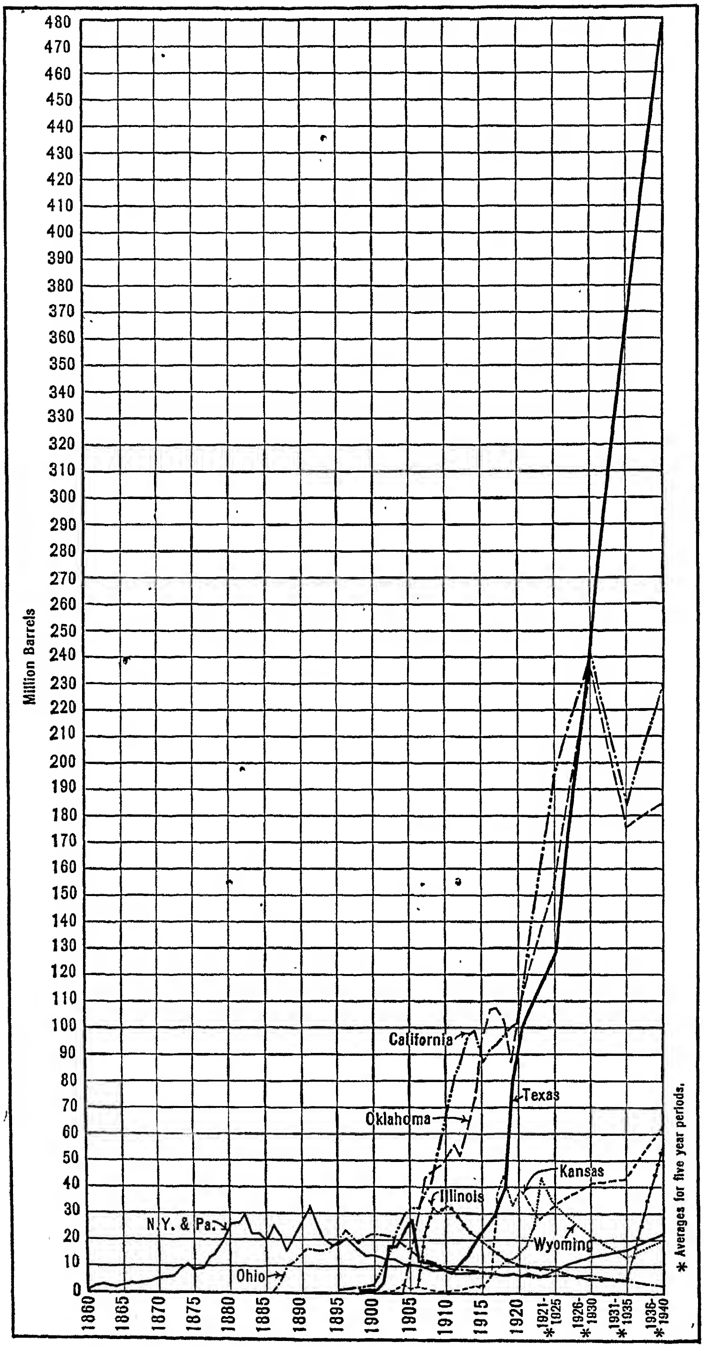


This forest of derricks results from the discovery of oil in a town, after which nearly everyone puts a well on his lot to get some of the oil. One or two wells would have taken the whole of it and each well may cost 50 to 75 thousand dollars. Think of the inconceivable waste! In Trinidad and in other places, where the oil belongs to the government, only a few wells are drilled.

Petroleum is indeed a highly elusive and fugitive resource, the development of which has long been characterized by uncertainty, haste, waste, vicious competition, and frequent overproduction. The one sure thing about petroleum is

[7] The petroleum surveyor sets off nitroglycerine charges at various points, and the different sound waves recorded on his seismograph reveal if there are dense subterranean areas or domes in the underrock where oil might be found. The torsion balance, which can record a change in rock density as small as one part in a million million, shows differences in gravitational pulls in various parts of a region and helps the surveyor to determine underground formations. The magnetometer records the magnetic pulls of different kinds of rocks and easily reveals the presence of sedimentary rocks, which are poor transmitters of the earth's magnetism. The electrical log shows the permeability of subterranean beds. The aerial camera exposes surface formations that might not be seen by the petroleum surveyor who travels on foot.

[8] See Erich W. Zimmermann, *World Resources and Industries,* Harper & Brothers, Publishers, New York, 1933, p. 531.



Graph of production by states. Petroleum is a meteoric industry. Notice the changes in state leadership. From 1920 on, periods represent only five-year periods, otherwise fluctuations would have been greater.

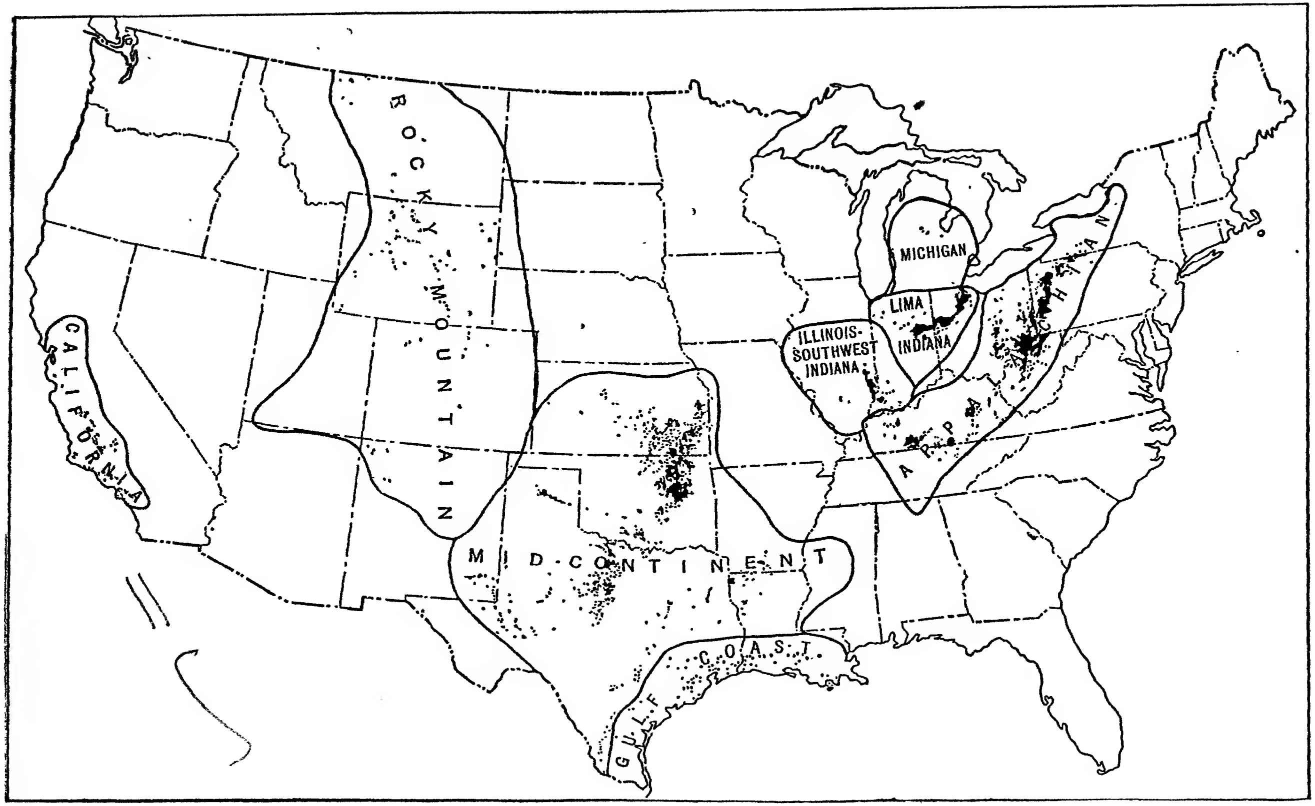
that it is exhaustible. When the last of this temporary resource has been used by man, there will be no more. Up until now the petroleum industry has been able to ward off the evil day of exhaustion through continuous prospecting, through the use of more scientific prospecting methods, through good luck in finding more petroleum deposits, through better drilling methods that can now bore 17,000 feet into the earth, and through improved refining technique that utilizes petroleum more efficiently. Fundamentally, however, the quest for oil is a race between discovery and disaster.[9] How long man will continue to discover new oil fields is a moot and vital question.

3. *The American Oil Fields*

American prominence in oil production has been largely due to the great wealth of our petroleum deposits, to the fact that petroleum was first developed on a large scale here, and to our leadership in automotive transportation with its increasingly voracious demand for gasoline. The phenomenal increase in American petroleum production has occurred since 1908, when the unprecedented output of 10,000 Ford cars in a single year ushered in the large-scale manufacture of automobiles. By the end of the nineteenth century nearly one billion barrels had been produced in the United States, by January 1, 1909, another billion barrels had been taken from the ground, and by January 1, 1942, the nation's output up to that time amounted to over 25 billion barrels. Of the total production prior to 1942, about 28% was produced in Texas, 24% in California, and 20% in Oklahoma, each of these states having produced more petroleum than Russia, which ranks next to this country in its cumulative output. In recent years the United States has been producing over three-fifths of the world's annual output of petroleum. Since 1936 our production has amounted to over a billion barrels a year, reaching a peak of 1½ billion barrels in 1941.

The Pioneer Appalachian Field. As the accompanying map (see Fig. 100) reveals, there are eight distinct petroleum producing regions or major oil fields in the United States, the importance of production in each field since 1900 being indicated by the data in Table 9. The oldest American oil field, known as the Appalachian, runs from southeastern New York, southwest through western Pennsylvania, southeastern Ohio, and the adjacent parts of West Virginia. Within 40 years after the discovery of the first well, this field had 20,000 deep wells and 4,000 miles of pipe line to collect the oil in storage tanks and carry it to refineries. Large towns bearing such suggestive names as Oil City, Olean, Petrolia, from small beginnings grew large, rich, and prosperous, and Pittsburgh, Cleveland, Erie, and New York were among the first great refining centers. Pennsylvania now produces only half of the maximum output of 33 million barrels which it achieved in 1891, and in 1941 the entire Appalachian field produced 33 million barrels, or about 2.5% of the nation's supply. The average yield of wells in this old field is only about half a barrel a day, but

[9] See Evan B. Alderfer and Herman E. Michl, *Economics of American Industry*, McGraw-Hill Book Co., Inc., New York, 1942, p. 236.



The oil fields of the United States. In 1943 the percentages were as follows: Mid-continental, 48.9; Gulf Coast, 19.7; California, 18.9; Illinois-Southwest Indiana, 5.8; Rocky Mountain, 2.9; Appalachian, 2.3; Michigan, 1.4; Lima-Indiana, 0.01.

These fields are also the natural gas fields of the United States.

the high quality of the oil and nearness to market enables Appalachian oil to command the highest price in the United States.

The Old Lima-Indiana Field. The second discovery of importance in the United States was the Lima-Indiana field, which crosses the northern part of the Ohio-Indiana boundary, with its center in Lima, Ohio. Commercial production got under way in 1876, Ohio reaching its peak two decades later. As the data in Table 9 reveal, this field is nearly exhausted, and the little output of 400,000 barrels in 1941 was obtained by the use of pumps. The new Michigan field, which was opened in the early 1920's, reached its peak production of 20 million barrels in 1939 which has since declined to about 16 million barrels. Oil was discovered in Illinois in 1889, reached a peak of 33 million barrels in 1910, and then declined. Important new discoveries and deeper drilling in the late 1930's have rejuvenated the Illinois-Southwestern Indiana field, the Salem, Louden, and Centralia districts being the leading producing centers. While production averaged only about 5 million barrels in 1931-35, by 1941 it had increased to more than 140 million barrels, the most remarkable petroleum development that has occurred east of the Mississippi River during the present century.

TABLE 9

PRODUCTION OF CRUDE PETROLEUM IN THE UNITED STATES, BY REGIONS, 1901–40

(Millions of barrels)

Region	*1901–10 (average)*	*1911–15 (average)*	*1916–20 (average)*	*1921–25 (average)*	*1926–30 (average)*	*1931–35 (average)*	*1936–40 (average)*
Appalachian.....	28.9	24.6	27.2	28.5	31.6	30.1	34.8
Lima-Indiana *..	17.3	5.1	3.5	2.3	1.7	1.1	0.6
Michigan.......	....	....	....	0.001	1.9	9.0	18.1
Illinois-S.W. Indiana *........	12.7	25.0	13.9	9.6	7.5	5.3	57.6
Mid-Continent....	25.1	87.7	184.6	343.6	527.9	566.3	694.8
Gulf Coast......	17.4	12.4	24.3	33.7	54.1	75.4	178.3
Rocky Mountain.	0.4	2.6	11.8	35.3	29.5	18.0	27.8
California.......	35.6	90.5	97.4	195.1	241.5	184.2	230.3

* Southwestern Indiana was reported with the Lima-Indiana region prior to 1921.

The Great Mid-Continent Field. The greatest petroleum region of all is the vast Mid-Continent field, which has yielded over half our output to date. Commercial production began in 1889 near the town of Neodesha, Kan., but important production in this field was not achieved until 1896, when the Corsicana pool was opened in Texas.[10] Pro-

[10] John G. Glover and William B. Cornell (ed.), *The Development of American Industries*, Prentice-Hall, Inc., New York, 1941, p. 329.

duction in Oklahoma was begun in 1902 and increased rapidly after the discovery of the Bartlesville pool in 1904 and the Glenn pool in 1906. Northern Louisiana started to produce oil in 1898, southern Arkansas in 1921, and southeastern New Mexico in 1923. Oklahoma City began its boom cycle in 1929, and the Kilgore boom in the following year unleashed a deluge of oil in East Texas. Thus, one new oil pool after another has come roaring in, each achieving temporary wealth and fame. At the present time about two-thirds of the total production of the Mid-Continent field occurs in Texas and Oklahoma, East Texas alone producing over two-fifths of the total output. In 1941 the Mid-Continent field yielded the staggering total of 718 million barrels, or 51% of the nation's supply. Apparently, this remarkable field has the largest proved reserves in the United States,[11] and production has not even approached its zenith.

The Gulf Coast Field. This field in Texas and Louisiana was opened with the discovery of the famous Spindletop pool near Beaumont in 1901, where the scramble for oil led to the drilling of six wells per acre, involving profligate duplication and waste. The oils of this field contain a low percentage of gasoline and a high percentage of sulfur and residue; hence, they are less valuable for refining than those of the Mid-Continent and Appalachian fields, but are particularly useful in the production of fuel oil. In the Louisiana section, production averages about 113 barrels of oil per well per day, which is the highest average yield per well in the United States.[12] This field has enjoyed its greatest prosperity since 1935, production in 1941 amounting to 226 million barrels, or 16% of the nation's output.

The Rocky Mountain Field. The development of petroleum in the Rocky Mountain field lies chiefly in the future, for this region is least accessible to the nation's leading markets. Small producing districts are scattered throughout this large region, which extends from central New Mexico to the Canadian border. Wyoming has about three-fourths of the region's reserves and in 1941 produced about three-fourths of the region's output of nearly 40 million barrels. Fortunately, thousands of acres of oil land are owned by the United States Government which may render great service in the future. Unfortunately, the proved reserves of the Rockies are less than 3% of the nation's total.[13]

California. This state has felt the exhilaration of many booms, including the famous Gold Rush, a wheat boom, a citrus boom, a movie boom, an almost continuous real estate boom, and also two of the country's greatest oil booms. While oil was produced in California as early as 1886, large-scale production did not get under way until the following decade when important discoveries were made in the Los Angeles and Bakersfield areas. From that time on, production increased rapidly, and California came to lead all states in 1909-14 and again in 1923-26. Maximum production was reached in 1929 amounting to 292 million barrels. In 1941 the Cali-

[11] Of the proved petroleum reserves amounting to 19 billion barrels in the United States on January 1, 1941, there were 10.6 billions in Texas, 3.3 billions in California, 1.2 billions in Louisiana, 1 billion in Oklahoma, and 0.7 billion in Kansas.—U. S. Dept. of Interior, *op. cit.*, p. 938.

[12] *Ibid.*, p. 959.

[13] *Ibid.*, p. 938.

fornia field yielded about 16% of the nation's supply, or 230 million barrels, about three-fourths of which was produced in Los Angeles and adjacent Kern and Orange counties. California oil serves the coal-poor Pacific coast, and large shipments of refined products are made through the Panama Canal to our eastern seaboard as well as to eastern Asiatic and Australasian markets. How long will it last? And then?

In view of the phenomenal developments in American petroleum history during the present century, it is difficult to realize that in 1900 the Appalachian and Lima-Indiana fields led the nation with outputs of only 36 and 22 million barrels respectively. Fame and fortune achieved through the exploitation of this fugitive resource are indeed ephemeral, since decline and exhaustion are the inevitable fate of every oil field, no matter how big, boisterous, and prosperous it may be at the present time.

4. *Substitutes for Petroleum*

Oil Shale. As the day of petroleum exhaustion draws nigh, man will be forced to turn to a diligent use of substitutes. One is oil shale. It exists in great quantities in the Rocky Mountains, which are estimated to contain 75 billion barrels of oil, the largest deposits being located in northwestern Colorado and northeastern Utah. In addition, about 17 billion barrels of oil are believed to be recoverable from the black shales of Kentucky and Indiana which may be mined by open-pit methods.

Distillation of the shale, however, is both difficult and expensive, as the crude oil is obtained by heating (distilling) the shale in great retorts, and the process has not been reduced to a basis where it can compete extensively with oil wells. The average grade of shale in this country will produce one barrel (42 gallons) of crude oil to the ton. At our present rate of petroleum consumption, the shale deposits of America have locked up in them sufficient oil to last us 70 years or more.

Oil has been produced from shale in the Midlothian section of Scotland since 1850, the industry achieving its maximum output in 1913, when 3½ million tons of shale were mined and retorted.[14] A ton of Scottish shale yields 26½ gallons of crude oil, which in turn is converted into gasoline, fuel oil, Diesel oil, gas oil, paraffin, wax, and coke. In recent years Scotland's production of shale oil has declined to less than half of its 1913 output, and in 1938 little Estonia displaced Scotland as the world's leading producer.[15] Estonian oil shale has been mined since 1918, and for about ten years the shale itself was burned almost entirely in place of coal in locomotives, in factories, and in homes. In 1938 Estonia recovered about 1½ million barrels of oil from shale, which met most domestic needs and allowed a surplus for export. The cost of shale gasoline was about 15 to 17 cents per gallon at the producing plant. Oil-poor Japan is reported to have obtained about one million barrels of oil from the shale

[14] National Resources Committee, *Energy Resources and National Policy*, Washington, January, 1939, pp. 321-322.

[15] In 1938 the world's output of shale oil amounted to 405,000 metric tons, of which 140,000 tons were produced in Estonia, 131,000 tons in Great Britain, 120,000 tons in Manchuria, 8,000 tons in France, and 2,000 tons in Italy. Russia is also a producer.—League of Nations, *Statistical Year-Book of the League of Nations, 1940-41*. Geneva, 1941, p. 128.

deposits near Fushun, Manchuria, in 1937.[16]

Liquefaction of Coal. At present coal is much more important than oil shale as a source of oils and gasoline. Gasoline obtained from the liquefaction of coal cost between 17 and 25 cents per gallon at European plants in 1937, in which year Germany was able to obtain 30% of her gasoline from coal.[17] Essentially, liquefaction of coal consists in breaking up the heavy coal molecules and reforming them into light hydrocarbons like those of petroleum.[18] Germany led the world in the liquefaction of coal, and her gasoline output from this source is reported to have increased from 950,000 tons in 1937 to over 2,500,000 tons in 1940, when World War II greatly curtailed her imports of petroleum.[19]

Benzol and Alcohol. Benzol is another substitute for gasoline that is recovered as a by-product of coke production, but the world's output of 6 million barrels in 1935 would have been large enough to supply only 1½% of the American demand for motor fuel. Low temperature coke plants obtain about two-thirds of a barrel of oil from a ton of coal, and if the entire bituminous coal output of the United States in 1935 had been subjected to low-temperature carbonization, the process would have yielded about 100 million barrels of motor fuel, or enough to supply about one-fourth of our needs.

Alcohol derived from the world's abundant supply of grain and sugar cane can be used as fuel in internal combustion engines, and in many oil-poor countries it is mixed with gasoline. Experience shows that if we had to rely exclusively upon alcohol under prevailing methods of production, the cost of motor fuel in the United States would be increased by 300% to 1,000%.[20]

The greatest problem confronting man when the day of petroleum exhaustion arrives will be the problem of lubrication. Castor oil is used as a lubricant for airplane motors. It and other vegetable oils can be used for special lubricating purposes, but as yet there is no good general substitute for petroleum oils and greases. Perhaps the chemist with his new technique of recombining molecules, called polymerization, will find the answer, but even he will need raw material.

5. *Foreign Oil Fields*

Russia and Rumania. As far as we know at the present time, most of the world's petroleum reserves outside of the United States are centered in southeastern Europe, the Near East, and Caribbean lands (see Table 10). Southeastern Europe has for a long time been an important producer of petroleum, Rumania leading the world prior to 1860 with an annual output of less than 4,400 barrels. In most years since 1873

[16] National Resources Committee, *op. cit.*, p. 322.

[17] *Ibid.*, pp. 321, 323.

[18] Additional hydrogen must be added, since the ratio of carbon to hydrogen in coal, which is about 16 to 1, must be reduced to 7 to 1, which is the ratio found in petroleum. This may be accomplished as a continuous process by hydrogenation, by the synthesis of water gas or, indirectly, from the manufacture of gas and coke.

[19] In 1938, 150,000 metric tons of gasoline obtained by the hydrogenation of coal were produced in Great Britain, 14,000 tons in France, and about 2,000 tons in Belgium.—League of Nations, *op. cit.*, p. 129.

[20] National Resources Committee, *Technological Trends and National Policy*, Washington, June, 1937, p. 159.

Russia has been our leading rival, the Russian output actually exceeding that of the United States in 1898-1901. Since 1936 Russia has produced over 200 million barrels of petroleum annually, or about one-tenth of the world's supply, most of which has come from the Baku field on and near the Apsheron Peninsula along the west coast of the Caspian Sea and from the Caucasian fields which are scattered north and south of the Caucasus Mountains and include the famous Grozny field that was nearly captured by the German armies during World War II. Railroads and a pipe line from Baku to Batum facilitate the movement of petroleum via the Black Sea to southern Russian ports and to oil-poor northwestern Europe. Petroleum from this region also moves by ship across the Caspian Sea, up the Volga River, and thence by rail to the industrial markets of European Russia. Among the more recent developments are the Emba field northeast of the Caspian Sea, the middle Volga fields near Kuibyshev, and the Ural and Turkestan fields. The island of Sakhalin east of the Siberian mainland produces about 4 million barrels of petroleum annually, and new discoveries are likely to be made in the vast Siberian domain in years to come.

The Rumanian oil fields east of the Carpathian Mountains, not far from the refining center of Ploesti, are the only important producing oil fields in Europe outside of Russia.[21] Rumanian oil moves by pipe line to the Danube port of Guirgevo and thence by barge up the river and through canals to interior European markets; and it also moves by pipe line to the Black Sea port of Constantsa and thence by tanker to northwestern Europe.

TABLE 10

PROVED PETROLEUM RESERVES ON JANUARY 1, 1936, AND PRODUCTION OF CRUDE PETROLEUM IN 1940

(Millions of barrels)

Country	*Reserves*	*Production*
United States	10,575	1,352
Russia	2,830	217
Iraq	2,475	26
Iran	2,150	79
Venezuela	1,350	185
Rumania	633	43
Netherlands East Indies	450	61
Mexico	420	44
Colombia	275	26
Peru	138	13
British India and Burma	111	10
Argentina	92	21
Trinidad	91	20
All others	375	52
Total	21,965	2,149

Source: Reserve data, estimates by V. R. Garfias and R. V. Whetsel, cited in National Resources Committee, *Energy Resources and National Policy*, Washington, January, 1939, p. 287. Production data, U. S. Dept. of Interior, *Minerals Yearbook, Review of 1940*, Washington, 1941, p. 1017.

The above table is valuable in giving production during a war year. Its estimate of reserves, in comparison to one in this paragraph, is typical of the continual revision of oil reserves upward that has accompanied improvement in technique of prospecting and drilling. In *Business Week*, October 6, 1945, Mr.

[21] In 1940 4.5 million barrels of crude petroleum were produced in Germany, 3.9 millions in Poland, 1.8 millions in Hungary, and 1.7 millions in Albania, as compared with the Rumanian output of 43.2 million barrels.

Wallace Pratt, Economic Geologist and Director of the Standard Oil Company of New Jersey, was quoted as estimating the proved reserves, i.e., the amount of oil that can be removed from present fields, for sale at present prices, at about 60 billion barrels. That is 10% of his estimate of the probable ultimate world reserves of petroleum. Mr. Pratt divided the ultimate reserves of 600 billion barrels as follows: United States 16.67%, Middle East 30%, Caribbean Basin 13.33%, U.S.S.R. 18.33%, Southwest Pacific 10%, rest of the world 11.67%.

The next estimate will probably differ from this one and it will probably peel the United States of America down a bit more. According to *Time* (December 27, 1943, page 77), we have drilled one well for every 3 square miles of our area, while the rest of the world has made one well to every 526 square miles. A deceptive element in our big number of wells is our insane town lot drilling.

Total production to date is about 30 billion barrels, 64% by the United States. The United States has 32% of the proved reserves, according to Mr. Pratt.

". . . and there is oil at Mosul [Iraq]." With these words David Lloyd George is said to have ended a speech in Parliament shortly after World War I. Rich oil land under a weak or corrupt government in a strategic location is a menace to world peace.

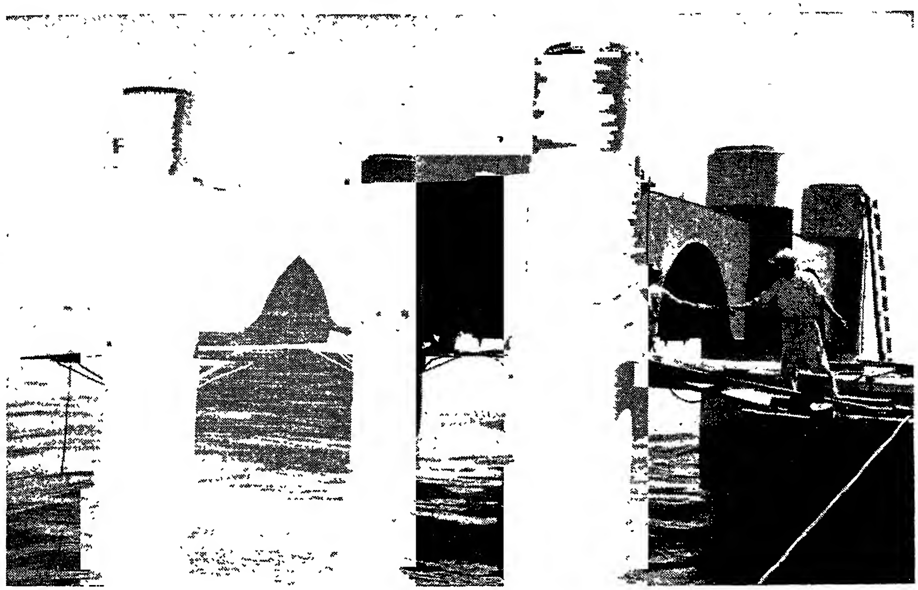
In February, 1946, published estimates gave Mesopotamia several times as much oil resources as the United States. Danger! Let us hope that this oil does not start another war.

Asiatic Fields. While the output of all the oil fields in Asia in 1940 was less than that of California, it is known that Iraq (Mesopotamia) and Iran (Persia) possess some of the world's largest petroleum reserves. The Iranian fields, northeast of the Persian Gulf and near the border of Iraq, have been exploited since 1913 by the Anglo-Iranian Oil Co., in which the British Government is the majority stockholder. In 1940 the Iranian output was surpassed only by that of the United States, Russia, and Venezuela. Crude oil is shipped by pipe line to the head of the Persian Gulf, where much of it is refined at Abadan, and Iranian fuel oil is of vital importance to the oil-burning ships that operate in southern Asiatic waters. The fields of Iraq, near Kirkuk and Mosul, were opened in 1920 and are now exploited by British, Dutch, French, and American oil companies that operate in close cooperation. A pipe line built by American engineers carries the crude oil across the desert to the Mediterranean ports of Tripoli, Syria, and Haifa, Palestine, some of it being refined at the latter port. In 1940 the fields of southwestern Asia produced about three-fifths of the continent's petroleum.[22]

From Iran eastward to California there are few petroleum fields of outstanding importance.[23] The greatest of

[22] The production of Siberian and Sakhalin fields are reported with European Russia and are not included in the Asiatic total. In 1940 about 7 million barrels of petroleum were produced on the British-owned island of Bahrein in the Persian Gulf, and 5 million barrels, in Saudi Arabia, where a new pipe line delivers oil to the terminal at Ras Tanura.

[23] In 1940 the output of fields east of Iran included: 61 million barrels in the Netherlands East Indies, 8 millions in Burma, 7 millions in Sarawak and Brunei, 2½ millions in Japan and Formosa (Taiwan), and 2 millions in British India. Extensive surveys in China by American experts resulted in no discoveries.



Lake Maracaibo, Venezuela, is so shallow that small boats carry out the oil. From the elaborate and substantial foundation shown in this picture, two wells will be drilled under water.

these are in the Netherlands East Indies, chiefly the Palembang and Djambi fields of northern Sumatra, which are served by the great refineries at Palembang, and the Sanga-Sanga field of eastern Borneo, which has a large refinery at Balikpapan. About 40% of the total investment in the East Indian petroleum industry in 1939 was American capital, the remainder being Dutch and British.[24] Another important field lies in the Irrawaddy Valley of Burma near Yenangyuang, where production is monopolized by three British companies.[25] Small refineries are located within the field, but most of the crude oil is conveyed by pipe line and a fleet of river tankers to the large refineries in Rangoon. Burmese oil provides not only kerosene for the lamps of Burma and India but also high octane gasoline for aviation in this part of the world.

Caribbean Fields. Within the Caribbean region Venezuela is now the leading producer of petroleum, and her reserves are apparently among the largest in the world. Production began in 1918, and a decade later surpassed that of Mexico. About four-fifths of the nation's output is produced in the immediate vicinity of Lake Maracaibo, and every barrel of oil is carried out to sea in specially built shallow-draft tankers that wait for high tide and sail in fleets across the sandbar at the northern neck of the lake. The crude oil is delivered to the Dutch islands of Aruba and Curaçao, where it is either transshipped to American and European refineries or is refined locally before moving to

[24] Kate L. Mitchell, *Industrialization of the Western Pacific*, Institute of Pacific Relations, New York, 1942, p. 198.

[25] *Ibid.*, p. 192.

foreign markets. Refineries on these small islands were recently reported to be the largest in the world.

A small part of the Maracaibo output is delivered to refineries on the Paraguana Peninsula which serve the Venezuelan market. In recent years new fields have been developed in the lower Orinoco Valley near Maturin and Ciudad Bolivar. Largely because of its huge royalties from the petroleum industry, the Venezuelan Government remained in an exceptionally sound financial condition throughout the depression years of the nineteen-thirties.[26]

Like Venezuela, Mexico has felt the intoxication of fabulous oil wealth and at times has ranked second only to the United States in petroleum production. Production began in 1901 on the coastal plain near Tampico, increased rapidly after 1910, reached its peak of 193 million barrels in 1923, declined to 33 million barrels in 1932, and has since increased to an output of 44 million barrels in 1940. Thus, in Mexico as in all oil fields the eventual, long-run trend is downward. In 1938 the Mexican Government expropriated the oil fields, much to the distress of the British and American companies that for years had enjoyed a highly lucrative investment. In contrast with the boom years of the early nineteen-twenties, most of the Mexican output is no longer exported but is consumed in the domestic market, where it is used extensively by the railroads and as industrial fuel. The most recent development of petroleum in the Caribbean area has occurred in Colombia, the first oil being shipped out of the country in July, 1926. The principal producing region includes the Infanta and La Circa fields in the lower Magdalena Valley, and most of the oil is shipped by pipe line to Cartagena for export, the remainder being refined at Barrancabermejo for domestic use. In 1940 the new Barco field near the Venezuelan border was opened up with the completion of a pipe line that carries the oil across mountains and through jungles to the Caribbean coast.

On the island of Trinidad oil is produced by private corporations on land owned by the British Government, and most of it is refined locally prior to export. Because of governmental control, no more wells are drilled than are necessary to obtain the oil. The flat plain east of the Rockies in the United States gives us the superrich Mid-Continent field. In South America we have the long Andes with flat plains at their base, already yielding in Colombia and Venezuela at the north and in Argentina, Bolivia, and Paraguay at the south. There are delicious unofficial stories of oil riches in Colombia. The ride through this oil field should bring blushes of shame to any American who has seen the forests of derricks in Texas, California or Pennsylvania. There are so few derricks in Trinidad that, as you ride along, you

[26] During the 1930's Venezuela had the highest public revenue per capita in South America, almost no internal debt, no foreign debt, a stable monetary unit based on gold, and no income or corporation profit taxes, all of which seems like a financial heaven. On the other hand, it should be noted that the high cost of living in the oil fields consumed the high wages of Venezuelan workers there, the high wages of the oil fields created a labor shortage in other regions, the dominance of petroleum retarded the development of other natural resources, and the maintenance of the gold standard helped to make the cost of living in Caracas and other cities higher than that in New York City. And, not least, the "private profit" obtained by the ruthless Gomez after oil began to gush enabled him to remain the nation's undisputed boss from 1908 until he died in 1935. And when the oil is gone—?

think you are *approaching* the oil field. Instead you are in the midst of it. It has only as many wells as it *needs*. The society that lets undiscovered oil belong to the landowner has, in this respect, no more horse sense than a cow has.

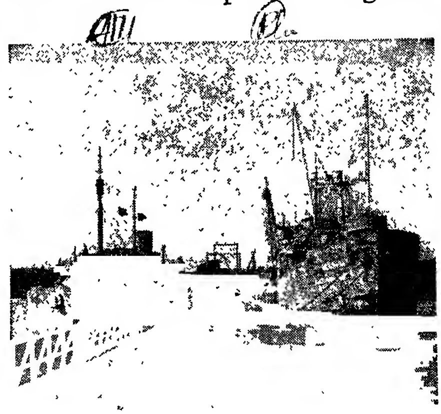
The little island of Trinidad, with its output of 20 million barrels, is the largest petroleum producer within the vast British Empire. Small wonder that the British are so keen after oil concessions. Where would they be without oil now that the Channel no longer defends them?

Minor South American Fields. South of the Caribbean lands the production of petroleum is much less important.[27] In Argentina the Comodoro Rivadavia field has been producing since 1907, and, in spite of the development of new fields in Mendoza and Salta east of the Andes, the country must import 40% of its petroleum supply. The Peruvian fields, concentrated in the extreme northern part of the coastal desert near Talara, achieved their peak output of 17½ million barrels in 1936. On the Santa Elena Peninsula of Ecuador petroleum is obtained chiefly by primitive methods; open pits are dug, the oil seeps up and is then dipped out. Although the petroleum output of these countries is comparatively small, the availability of this liquid fuel is a great blessing to many transportation, manufacturing, and mining enterprises that otherwise would have to depend upon coal imported from distant sources.

Probably the next scramble for oil in South America will occur in the vast, hostile, nearly empty, and generally inaccessible Gran Chaco region of eastern Bolivia, western Paraguay, and northern Argentina, for this region is believed to contain large but unproved oil reserves.

6. *The Transportation and Refining of Petroleum*

Two important geographical facts account for the development of large-scale



Two tankers discharging their cargo in the harbor of Portland, Maine. Crude oil is rarely lifted in America save by the power of a pump.

transportation of crude petroleum and the products that are refined from it. First, very few oil fields are located near the densely populated, highly industrialized areas that comprise the leading

[27] In 1940 20 million barrels were produced in Argentina, 13 millions in Peru, and 2 millions in Ecuador.

markets for petroleum and its products. Second, the great bulk of the world's crude oil is produced in a few regions, whereas virtually every nation consumes petroleum products. The problem of handling this inflammable fuel has been difficult.

Improvements in Transportation. In the years that followed Drake's discovery of oil near Titusville, Pa., petroleum was carried in kegs and barrels by whatever mode of transport was available, which sometimes involved carriage on horseback, in wagons, flatboats and barges, and railway cars before the oil reached the refinery, and from there the finished products were delivered to the consumer in barrels.[28] The labor and expense of moving petroleum in barrels soon led to improved methods of transportation. The first pipe line was laid in 1862, and by 1874 pipe lines had reached Pittsburgh.[29] Wooden tank cars were first used on the railroads in 1865, which were soon superseded by larger and better tank cars made of steel. On the high seas the movement of petroleum and its products in barrels gave way to shipment in four-gallon square tins or cases, which in time gave way to specially built tank ships holding thousands of barrels.

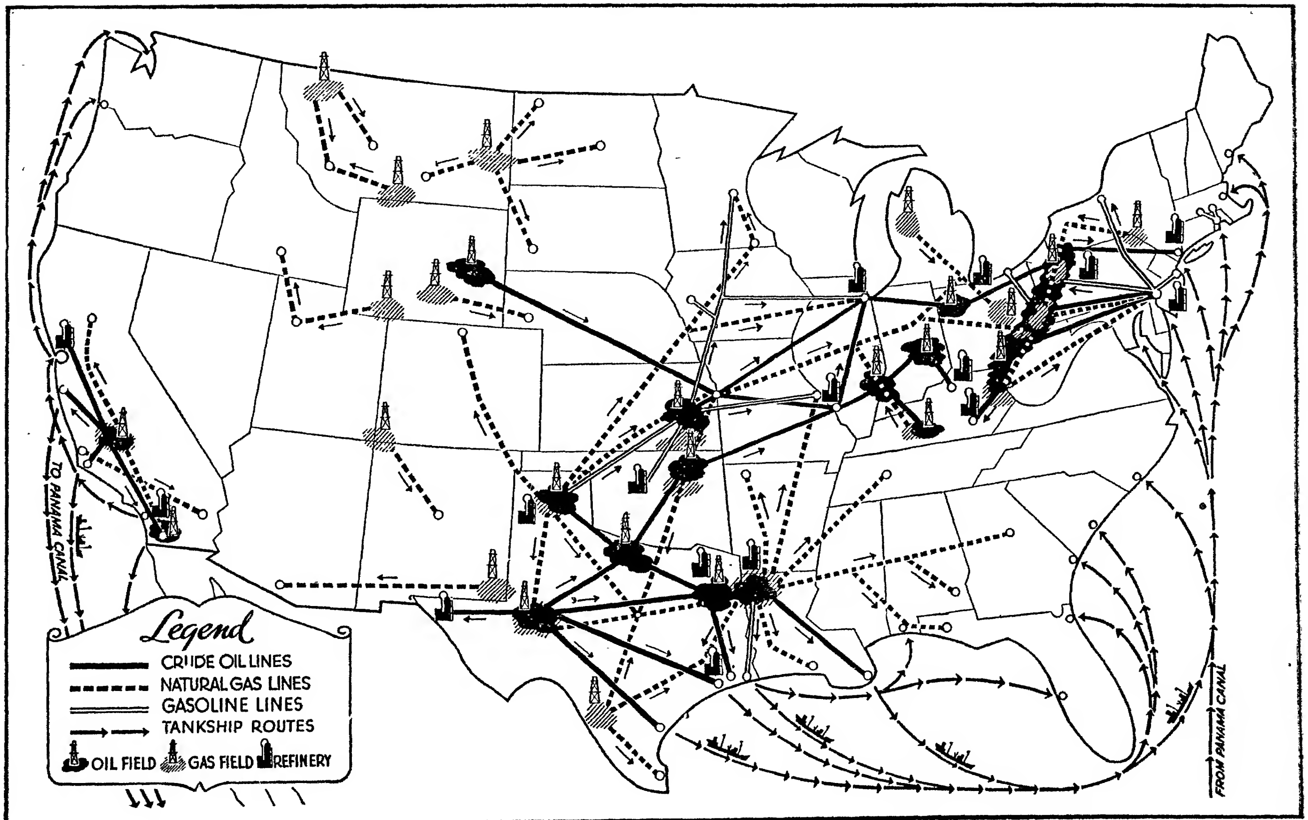
In 1941 a vast network of more than 105,000 miles of pipe line served the United States, connecting such distant points as the oil fields of New Mexico, Colorado, and Wyoming with the terminals and refineries along our Gulf Coast and North Atlantic seaboard (see Fig. 114). The main trunk lines consist of steel pipes, 8 to 12 inches in diameter, through which oil is moved at the rate of about 3 miles per hour by the pressure created by Diesel engines or electric pumps, which are spaced at 10- to 50-mile intervals. It is estimated that the cost of transporting a ton of crude oil a mile is seven-tenths of a cent by railroad or motor truck, three-tenths of a cent by pipe line, and only one-tenth of a cent by tank ship.[30] Since the bulk of our petroleum is produced in the Mid-Continent and other interior fields, pipe-line transportation is indispensable, and in U.S. 1940 72% of all crude petroleum in this country was delivered to the refineries by pipe lines, 25% by tank ships, and only 3% by tank cars and trucks. While a growing network of gasoline pipe lines (see Fig. 111) has increased the importance of refining within the oil fields, only about 4% of refined petroleum products in the United States move by pipe line, transportation of these products being about equally divided between rail and water carriers. The chief function of the ubiquitous motor truck is in the delivery of gasoline, kerosene, and fuel oil from the refineries and tank ships to nearby markets.

Location and Problems of Refining. Two years before Drake drilled his famous oil well, petroleum refining was born at Yale University when Benjamin Silliman, Jr., discovered that the specimen of "rock oil" that had been sent to him from western Pennsylvania was

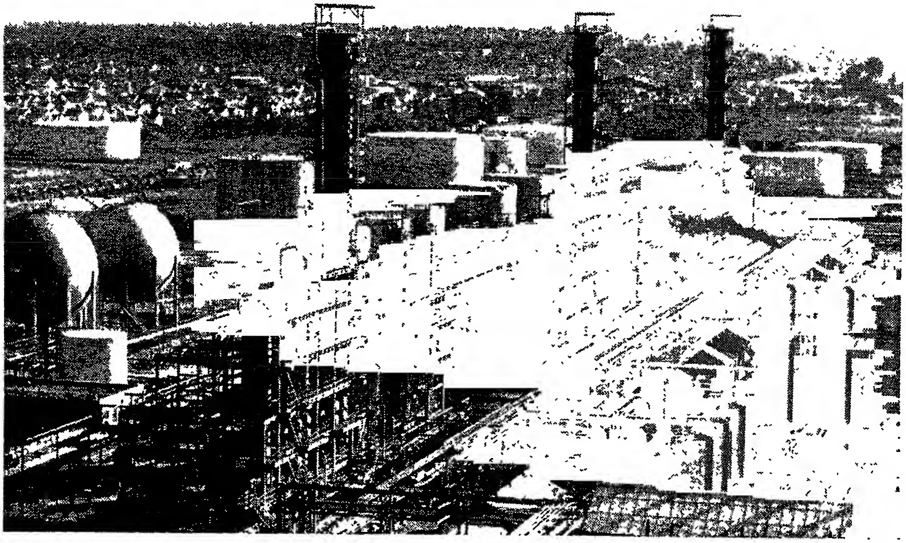
[28] During America's first oil boom teamsters earned $2.50 to $5.00 per barrel carrying oil in wagons 8 to 20 miles to Oil Creek. In the process of floating oil downstream, about 1,000,000 barrels of oil were lost, owing to floods and poorly constructed boats and equipment.—National Resources Committee, *Energy Resources and National Policy*, p. 152.

[29] See *ibid.*, pp. 359-360, and John G. Glover and William B. Cornell, *op. cit.*, pp. 330, 332.

[30] Evan B. Alderfer and Herman E. Michl, *op. cit.*, p. 242.



Pipe lines and ship lines. Without either pipe lines or tankers, large parts of the United States would be strangely immobilized. During World War II, when the German submarines were sinking tankers in the Atlantic so rapidly, pipe lines from Philadelphia inward had to be reversed to carry oil toward the East, and the special new emergency "Big Inch" pipe line was built from Texas to New York.



Part of an oil refinery at Baton Rouge, Louisiana. An inkling of the size of the thing is given by the stairs and the open stories in the building at left foreground. Hundreds of chemists and chemical engineers have striven to bring this technology to pass.

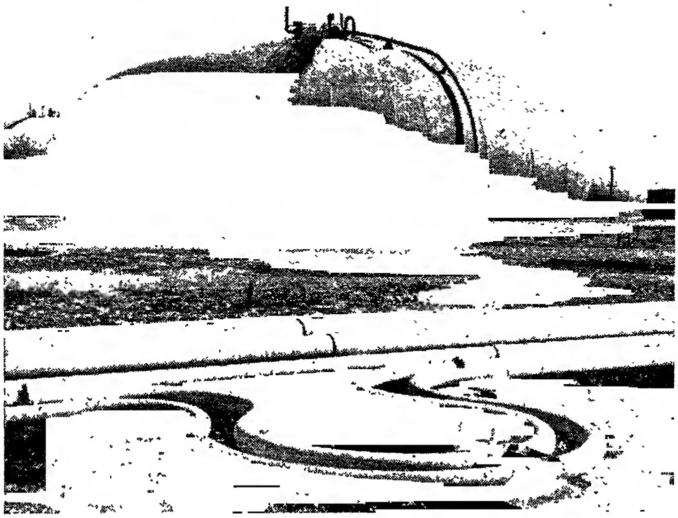
a complex hydrocarbon compound that could be separated easily into various products by distillation.[31] In the simplest form of refining, or distillation, the thick, black crude oil is put in a large tank and heated so that one product after another becomes volatilized and passes off like steam from a kettle, to be caught and condensed. The application of heat at first drives off the lightest products—the gases, naphtha, and gasoline. As the heat is increased, heavier products are obtained, such as kerosene, fuel oil, lubricating oil, and finally waxes, asphalt, and a final residue of coke. Each product is capable of separation into others by redistillation, and every year more and more products are derived from petroleum. Yet, among the hundreds of by-products obtained by modern refining, gasoline, fuel oil, and lubricating oil are most important commercially, as they yield about 90% of the total revenue of the refining industry.[32]

Refineries vary greatly in size, their capacities ranging from less than 10,000 to over 150,000 barrels of crude oil daily, and in 1941 the 562 refineries in the United States had an aggregate capacity of 4.9 million barrels per day. So highly mechanized are operations in modern refineries that about the only labor needed is that of maintenance and repair crews and men who read the gauges and manipulate the valves, with the result that labor costs are only about 5% of the value of the total product.[33] On the other hand, capital costs are tremendous not only because of the huge

[31] National Resources Committee, *op. cit.*, p. 157.

[32] Evan B. Alderfer and Herman E. Michl, *op. cit.*, p. 240.

[33] *Ibid.*, p. 242.



A corner of a spheroid tank farm—the largest in the world—in Aruba, Dutch West Indies, using Venezuelan oil. The great curves in the pipes in the foreground are to avoid troubles resulting from expansion and contraction along ~~straight pipes.~~

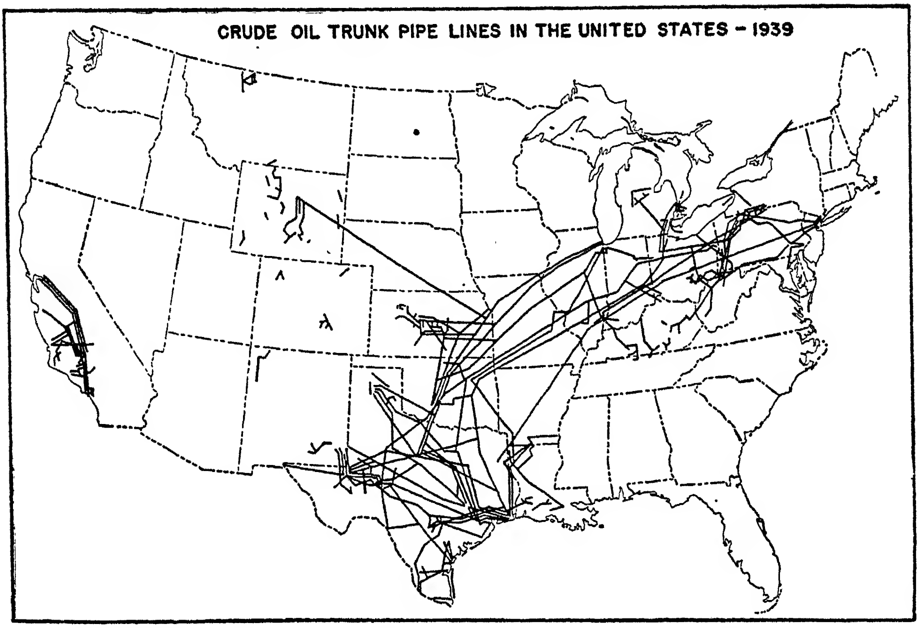
investment in expensive equipment but also because the equipment depreciates rapidly under the continuous high temperatures and pressures that are used. Furthermore, rapid changes in the technology of refining make equipment obsolete and the installation of new equipment necessary within a few years.[34] Each year the large companies spend millions of dollars on laboratory research, employing the services of highly trained and well paid chemists and other technicians who constantly endeavor to improve old products, find new uses for them, and discover new derivatives of petroleum that will be of service to man.[35]

Since the advent of the automobile and the airplane and the development of high speed and high compression motors, the major problem of the petroleum chemist has been to obtain more and better gasoline from each barrel of crude oil. As a consequence of chemical research, simple distillation was replaced by straight-run refining, which in turn was surpassed by thermal cracking.[36] In the cracking process the gas-oil distillate, which was formerly a drug on the market, is subject to great temperature and pressure and is broken down into gasolines of higher anti-knock qualities. Whereas simple distillation seldom yielded more than 10% gasoline and

[34] Most of the 120 refineries that were idle in this country in 1938 will probably never be used again because of their obsolescence, even though most of the equipment had been in use only 5 to 10 years.—*Ibid.*, p. 243.

[35] One such development during World War II was the production of butadiene, which is used in the manufacture of synthetic rubber.

[36] In simple distillation the crude oil is placed in a single tank, where all evaporation takes place. In straight-run refining crude oil passes through a series of tanks, each having the proper temperature to evaporate one set of hydrocarbons. Thermal cracking was first used in 1912, but it was not until 1936 that the volume of cracked gasoline exceeded the output of straight-run refining.



Crude oil trunk pipe lines in the United States. This map shows that the previous map was a bit symbolic—space forebade and here the lines of one type are shown complete.

straight-run refining seldom more than 25%, thermal cracking makes possible the recovery of 65%. As a consequence of the increased use of cracking, the portion of crude oil converted into gasoline in the United States increased from 18% in 1914 to 44% in 1941. The recent development of catalytic cracking threatens to displace thermal cracking, and the use of hydrogenation in conjunction with cracking and polymerization now make possible the complete conversion of crude oil into motor fuel.[37] Because of the availability of these new processes, our refining industry stands ready to supply virtually any petroleum product in any proportion from any grade of crude oil. Without these processes, the American motorist would not enjoy the superior motor fuel of today, and the 100-octane gasoline used by American aviators during World War II would have been utterly impossible. Above all, these new processes mean a more effective use of our dwindling petroleum reserves.

[37] Catalytic cracking produces gasoline by heating either crude oil or gas oil distillates and passing the vapor through a catalyst. Hydrogenation goes farther than cracking; it also breaks down the heavy hydrocarbon molecules under great pressure and heat, but it makes use of a catalyst to inject hydrogen into the newly created molecules, which improves the quality of the gasoline and builds up the quality of all the oil that is used. Polymerization is essentially the reverse of cracking, for, instead of breaking down the molecules of the heavier hydrocarbons, it produces gasoline by building up the lighter gases from petroleum refining as well as propane and butane obtained from natural gas. It has been estimated that the amount of gasoline that can be made by the polymerization process from noncondensible gases would equal 10% to 25% of the total gasoline consumption in the United States.—See *ibid.*, 243-245, and National Resources Committee, *Energy Resources and National Policy,* pp. 160-161 and 363-368.

While petroleum refineries are to be found in 37 states, six states refine over three-fourths of all petroleum, namely, Texas, California, Pennsylvania, Indiana, Illinois, and New Jersey. Of 1,294 million barrels of crude oil run through American refineries in 1940, 383 millions were refined along our Gulf Coast, 205 millions along our northeastern seaboard, and 201 millions in California. Petroleum refining, like petroleum production, has moved steadily westward and southwestward, as the accompanying map (Fig. 111) reveals. The calculated geographical center of petroleum production lies in the Texas Panhandle, and the center of refining is in northeastern Oklahoma, whereas the center of population is in southwestern Indiana.[38] These facts indicate that the location of petroleum refining is the result of a delicate balance of forces involving nearness to market, nearness to raw material, and the availability and cheapness of transportation. Because of high railway rates on finished products, most field refineries are restricted to local markets, although the coming of the gasoline pipe line has liberated some of them from this handicap. On the average, seaboard refineries are six times as large as those in the interior.[39] Those along the Gulf Coast of Texas and Louisiana assemble their crude oil by pipe line from Mid-Continental and nearby fields, serve local markets, and ship huge surpluses of refined products by tanker to our northeastern seaboard and overseas, Texas being our leading exporter of crude oil and gasoline.[40] California refineries have the combined advantages of a very short haul in assembling crude oil, a large coal-poor market along the Pacific Coast, and a seaboard location, California ranking second to Texas in the export of crude

Laborer disposing of one of the end products of the refinery—pouring melted asphalt from a pipe into paper barrels.

oil and gasoline.[41] The refineries along our northeastern seaboard have the outstanding advantage of nearness to tremendous markets and obtain their crude oil by pipe-line and water transportation. Refineries in such cities as Cleveland, Chicago, and St. Louis are primarily market refineries, since their chief advantage is a short rail or truck

[38] *Ibid.*, pp. 144, 148.

[39] Evan B. Alderfer and Herman E. Michl, *op. cit.*, p. 242.

[40] In 1940 intercoastal shipments from Gulf Coast to East Coast ports consisted of 266 million barrels of refined products and 162 million barrels of crude oil.

[41] In 1940 intercoastal shipments from California to East Coast ports consisted of 6 million barrels of refined products and 0.7 million barrels of crude oil.

haul in the distribution of finished products to important markets that are close at hand, their crude oil supply being obtained by pipe line from Mid-Continental and nearby fields.

Asphalt and Wax. Asphalt, supposed to be an oxidized form of crude petroleum, is a common accompaniment of oil fields, its presence at the surface often pointing out the existence of oil that has evaporated. While used in the manufacture of many products, the chief use of asphalt is in the paving and roofing industries. For many years it has been mined commercially in France, Italy, and other European countries, but the best natural asphalt deposits are near the mouth of the Orinoco River in Venezuela and on the adjacent British island of Trinidad. The famous asphalt lake of Trinidad has furnished thousands of tons of this much prized paving material annually for half a century without lowering its surface more than a few feet. The lake is apparently inexhaustible and the very slightly viscous material permits trucks to drive over, and men dig it out in big chunks with picks, after which it slowly replaces itself within a few hours. The lake is less than a mile from the seashore and cable ways with traveling buckets transfer the asphalt easily from the lake to the holds of the ships, which carry it to the world's commercial ports.

Because of the ease with which Trinidad asphalt can be gathered and shipped, it led in the markets until the enormous production of petroleum furnished a new source. Most of our asphalt is now recovered directly from petroleum in the refining process as residual by-product.

In 1940 American refineries produced 5,347,000 tons of petroleum asphalt, and 125,000 tons were imported; in that year 491,000 tons of bituminous rock asphalt were mined in the United States, and we imported 12,000 tons of native asphalt, including 8,000 tons of lake asphalt from Trinidad.

Ozokerite, or mineral wax, a material somewhat resembling paraffin, is found in several oil fields and makes the brightest of all candles. It exists in great quantities in the Russian oil regions, but practically all the world's supply is gathered in Galicia, Poland, where there are even richer deposits along with a labor supply more abundant than in any other existing oil field.

7. *World Trade in Petroleum*

Principal Exporters. Less than one-third of the world's annual output of petroleum, crude or refined, enters into the channels of international trade, which is chiefly due to the fact that the United States and Russia are not only the two largest producers but also the two largest consumers. In 1938 the United States produced 61% and consumed 55% of the world's entire petroleum output, while Russia produced and consumed about 11%.[42] In that year American crude oil exports exceeded imports by 51 million barrels, while the export balance of refined liquid products was 89 million barrels, whereas Russia, busily engaged in expanding industry and preparing for war, consumed

[42] Charles K. Leith, James W. Furness, and Cleona Lewis, *World Minerals and World Peace*, The Brookings Institution, Washington, 1943, p. 74.

virtually her entire output at home.[43] With the major exception of the United States, the world's great exporters of both crude and refined petroleum are nations with small domestic markets.[44] In 1938 the world's leading exporters of crude petroleum were Venezuela, the United States, Iraq, Colombia, Peru, Mexico, and Iran, and the principal exporters of refined products were the Netherlands West Indies (Curaçao and Aruba), the United States, Iran, the Netherlands East Indies, Rumania, Trinidad, and Mexico.[45] While the great bulk of the exports of crude and refined petroleum move to the oil-poor markets of western Europe, petroleum products are sold in virtually every nation and are consumed in some of the most remote parts of the earth.

Wide Sale of Products. The worldwide distribution of petroleum products is well illustrated by the sale of American kerosene, as it is distributed more universally to the nations of the world than any other product of American export. It goes alike to Greenland and New Zealand, Norway and Madagascar, to the tribesmen in Italian East Africa, and to the Italian in the home country, to the Spaniard in Spain, and the Spanish-speaking mestizos of the Philippines. The Chinese, who regard light as a most prized luxury, buy large quantities of American refined oil. The ordinary 4-gallon cans of American kerosene are distributed throughout the interior of China in places where the face of the white man has never been seen. And the empty oil can, what services does it not render, from house roof to city water supply (by way of vendors)! In 1940 the export of American kerosene amounted to 19 million barrels, as compared with exports of 35 million barrels of fuel oil, 25 million barrels of motor fuel, and 10 million barrels of lubricating oil.

8. *Natural Gas*

American Production. The commercial production of natural gas in the United States began in 1820, when gas was conveyed from a shallow well through a lead pipe to 30 domestic consumers in Freedonia, N. Y. In 1872 gas was piped into Rochester, N. Y., and Titusville, Pa. From an output of about 2 billion cubic feet in 1880, production in this country has increased to 2,770 billion cubic feet in 1941. For many years the distribution of gas did not exceed a radius of 100 to 250 miles, but the discovery of huge gas fields in Louisiana, the Texas Panhandle, and elsewhere was followed by the construction of welded pipe lines, 18 to 26 inches in diameter, capable of transporting gas under high pressure with negligible loss for 1,000 miles or more.[46] As a consequence, the geographical center of nat-

[43] Russian exports of crude and refined petroleum declined steadily after 1932, and in 1938 no crude oil and only 7.8 million barrels of refined products were exported.

[44] In 1938 Mexico consumed over half of her output of crude and refined products.

[45] In 1938 world trade in crude petroleum amounted to about 338 million barrels. Exports from leading countries, in millions of barrels, were: Venezuela 186, United States 75, Iraq 30, Colombia 19, Peru 9, Mexico 5, and Iran and Bahrein 3. World trade in gasoline, fuel oils, kerosene, and lubricating oils amounted to 462 million barrels, and exports from leading countries, in millions of barrels, were: Netherlands West Indies 143, United States 102, Iran 64, Netherlands East Indies, 47, Rumania 29, Trinidad 12, and Mexico 9.—Charles K. Leith, James W. Furness, and Cleona Lewis, *op. cit.*, pp. 243-244.

[46] National Resources Committee, *op. cit.*, p. 295.

ural gas production has migrated since 1909 from southeastern Ohio to central Oklahoma (see Fig. 111), and the nation is now served with a network of 90,000 miles of pipe lines that carry the gas of 26 states (see Fig. 111).

While gas is found in many areas that do not produce petroleum, approximately half of the natural gas in this country is produced in conjunction with petroleum,[47] and it separates itself from oil as cream separates from milk. Hence, while the major natural gas and petroleum producing regions are coterminous, many gas fields lie outside of specific petroleum-producing areas. Yet the relationship between petroleum and natural gas is close, for it is estimated that the Mid-Continent, Gulf Coast, and California regions contain about 90% of the gas reserves,[48] and in 1941 the great oil producing states of Texas, California, Louisiana, and Oklahoma produced about 80% of the nation's gas supply.[49] In spite of improved methods now used in many fields, a vast amount of gas that is struck in drilling for oil is still wasted, being allowed to burn or blow away. The conservation of petroleum and natural gas has been a peculiarly difficult problem where everyone owning as much as a backyard is free to dig a deep hole in the earth and let them run out. Thus the desire to get some oil causes every landowner to dig a well. Thus twenty wells (at $15,000 to $40,000 each) may be dug where one would get all the oil. For many years the gas thus going to waste from oil wells in the United States was probably worth at city prices over half a million dollars, but to put a cash value on it at today's prices is somewhat like appraising the baby at so much per pound, pork price. Our intelligence, as a nation, in handling natural gas has been strictly bovine, if not ovine.

Chief Uses. For many years the industrial uses of natural gas have been much more important than the domestic and commercial use of gas for heating buildings. Of the 2,672 billion cubic feet of natural gas consumed in 1940, 89% was first treated for the recovery of natural gasoline before it was used for other purposes.[50] Of the nation's total consumption, 78% was used for industrial purposes, 17% for domestic fuel, and 5% for commercial uses. The principal industrial uses include the burning of gas as fuel in the gas and petroleum fields for operating natural gasoline recovery plants and for drilling and pumping operations; the use of gas as a raw material in the production of carbon black;[51] and the use of gas as fuel in Portland cement plants, electric power plants, petroleum refineries, glass factories, iron and steel plants, chemical works, and mines.

Natural gas is the best and most convenient fuel in the service of man, and very few countries enjoy its blessings. In 1938 the United States produced

[47] National Resources Committee, *op. cit.*, p. 295.

[48] In 1935 reserves were estimated at 90.1 trillion cubic feet, distributed as follows: Mid-Continent and Gulf Coast, 52.2%; California, 37.7%; Appalachian, 7.8%; Rocky Mountain, 2.2%; and North Central States, 0.1%.—*Ibid.*, p. 297.

[49] In 1940 Texas produced and marketed 1,064 billion cubic feet of natural gas; California, 252 billions; Louisiana, 343 billions; and Oklahoma, 258 billions.

[50] Gasoline obtained from natural gas is so light that it is usually blended with other gasolines before it is sold for use. The output of natural gasoline in 1940 was 2.3 billion gallons.

[51] Carbon black is used in the manufacture of tires, ink, and paint. In 1940 the output was about 569 million pounds.

88.5% of the world's supply; Russia, 3.5%; minor production occurring in Rumania, the Netherlands East Indies, and elsewhere.[52] The great pity is that the life of the gas well is so short, lasting only a few decades. On the basis of natural gas towns have risen, thriven, and melted away.

9. *The Significance and Distribution of Water Power*

A Permanent Resource. Coal and oil and gas in time will go, but water power will remain. As long as the rains and snows from heaven fall upon this earth, as long as water runs down to sea to be lifted by the sun through evaporation and wafted over the lands to start its journey anew, man will have at his disposal a perpetual source of power. Water is wasted if not used, and to use it is to conserve it. Wise are those nations that make intensive use of water power, supplementing it with their exhaustible supplies of mineral fuels. From the viewpoint of permanency, water power has no rival among the great sources of energy used by man today.

Popular Misconceptions. The average American mind holds many erroneous ideas about water power. Probably the most popular misconception is in regard to the importance of water power, for many people assume that virtually all of our electricity and most of our energy supply are derived from water power. The fact is that in 1941 only 30.5% of the electric energy produced in the United States was generated by hydroelectric plants. Of the total energy supplied by mineral fuels and water power, 52.2% was produced from coal, 33% from petroleum, 11.3% from natural gas, and only 3.5% from water power. Indeed, it has been estimated that if every drop of water falling as rain in the United States could be transformed into power at existing gradients, the supply of energy would not equal that derived in most years from coal.[53] Furthermore, it is probable that not more than one-tenth of the world's total daily output of work is accomplished by the use of water power[54] (see Table 2). A second misconception concerns the cheapness of water power. Many people believe that simply because it rains and water runs down hill, therefore water power is a free gift of nature and is very cheap. True, water power is a gift of nature, but so are coal, oil, and gas, and all require the expenditure of capital and labor before they can be of service to man. Hundreds of millions of dollars are spent in the construction of dams alone, Grand Coulee costing $111,150,000. While there are exceptions, hydroelectric plants ordinarily involve a cost of more than $150 per kilowatt capacity as compared with $75 to $125 for steam-electric plants. A third popular fallacy exists regarding the transportation of power. Many people think that only poles and a power wire are needed to convey electricity from the hydro-electric dam to any spot where it may be needed. As a matter of fact, the practical transmission of large blocks of power is re-

[52] Charles K. Leith, James W. Furness, and Cleona Lewis, *op. cit.*, p. 38.

[53] It is also estimated that if the entire run-off could be put to work, water power would yield the energy equivalent of 437,000,000 tons of coal. —National Resources Committee, *op. cit.*, p. 56. In 1941 our output of anthracite and bituminous coal was 568,000,000 tons.

[54] Thomas T. Read, *op. cit.*

TABLE 11

THE WORLD'S POTENTIAL AND DEVELOPED WATER POWER, JANUARY 1, 1942

Continent and country	*Capacity of water-power plants, 00 omitted*	*Potential water power available 95% of the time, 000 omitted*
Africa	2,100	274,000
Asia	86,690	151,000
Europe	301,430	74,000
North America	296,120	77,000
Oceania	13,320	21,000
South America	16,650	75,000
Approximate world total	716,310	672,000
North America:		
Alaska	451	1,400
Canada	88,450	25,500
Costa Rica	310	1,400
Guatemala	350	2,100
Honduras	75	1,400
Mexico	4,700	8,500
Newfoundland	2,510	600
Nicaragua	7	1,100
Panama (including Canal Zone)	400	700
Salvador	50	300
United States	198,160	33,500
West Indies	660	200
Total	296,123	76,700
South America:		
Argentina	670	5,400
Bolivia	220	3,600
Brazil	11,139	36,000
British Guiana		3,600
Chile	2,250	3,600
Colombia	250	5,400
Dutch Guiana		1,100
Ecuador	210	1,300
French Guiana		700
Paraguay	5	2,800
Peru	1,752	6,400
Uruguay		400
Venezuela	150	4,300
Total	16,646	74,600
Europe:		
Belgium	320	Small
Bulgaria	700	300
Czechoslovakia	3,100	700
Denmark	160	30
Eire	1,400	300
Estonia	200	100
Finland	8,200	2,500
France	54,000	6,000
Germany	37,000	3,500
Great Britain and Northern Ireland	5,500	700
Greece	100	350
Hungary	50	160
Iceland	180	700
Italy	62,500	6,100
Latvia and Lithuania	1,000	150
Netherlands	10	25
Norway	33,083	16,000
Poland	1,280	1,350
Portugal	1,088	450
Rumania	1,270	3,000
Spain	14,050	5,700
Sweden	25,460	4,000
Switzerland	30,480	3,600
Turkey		Small
Union of Soviet Socialist Republics	17,800	14,000
Yugoslavia	2,500	4,000
Total	301,431	73,960
Africa:		
Algeria	4	300
Angola	40	5,700
Bechuanaland	...	30
Belgian Congo and Belgian mandate	700	130,000
British Central Africa	...	1,700
British East Africa	62	6,700
British Somaliland	...	Small
Egypt	100	850

TABLE 11 (*Continued*)

THE WORLD'S POTENTIAL AND DEVELOPED WATER POWER, JANUARY 1, 1942

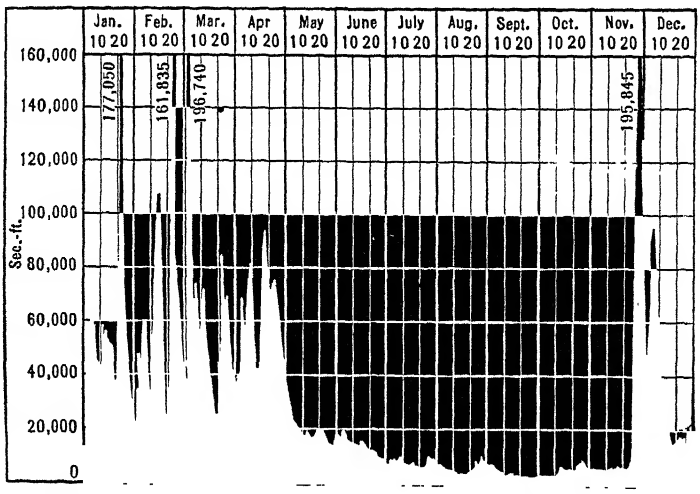
Continent and country	*Capacity of water-power plants, 00 omitted*	*Potential water power available 95% of the time, 000 omitted*	*Continent and country*	*Capacity of water-power plants, 00 omitted*	*Potential water power available 95% of the time, 000 omitted*
Africa: (*Continued*)			Asia:		
Eritrea	...	Small	Afghanistan	20	700
Ethiopia	7	5,700	Arabia		...
French mandate in Cameroons	...	18,500	Asia Minor	483	700
French Congo	...	50,000	Chinese Republic	35	22,000
French Guinea	...	3,000	Chosen (Korea)	11,450	3,000
French Sudan	...	1,400	French Indo-China	2	6,000
Gambia	...	Small	India and Ceylon	6,188	39,000
Gold Coast and British mandate in Togo	...	2,000	Iran (Persia)	11	300
Italian Somaliland	...	Small	Japan	61,340	7,200
Ivory Coast, Dahomey, and French mandate in Togo	...	4,000	Manchukuo	2,948	1,000
Liberia	...	5,700	Siam and Malay States	500	5,700
Madagascar	45	7,000	Taiwan (Formosa)	2,370	1,000
Mauritius	10	Small	Union of Soviet Socialist Republics	1,345	64,000
Morocco	710	350	Total	86,692	150,600
Nigeria and British mandate in Cameroons	110	13,000	Oceania:		
Portuguese East Africa	...	5,000	Australia and Tasmania	2,500	1,000
Portuguese Guinea	...	Small	Borneo, including New Guinea and Papua	50	10,500
Rhodesia	25	3,500	Celebes	5	1,400
Rio de Oro	...	350	Hawaii	320	150
Sierra Leone	...	2,500	Java	1,400	1,100
Southwest Africa (Union of South Africa mandate)	...	200	New Zealand	8,195	2,000
Tanganyika (British mandate)	80	4,000	Philippine Island	645	2,000
Tangier	...	70	Sumatra	200	3,000
Tripoli	...	Small	Total	13,315	21,150
Tunisia	...	40			
Union of South Africa	110	2,300			
Total	2,093	273,890			

Source: U. S. Geological Survey, *Developed and Potential Water Power of the World,* mimeographed bulletin 176,888, Washington, January 8, 1942.

stricted at present to a radius of about 300 miles. Hydro-electric energy must be produced at the water-power site, whereas the mineral fuels can be transported to power plants located in the midst of the market.

Distribution of Potential Resources. In order that the rivers of a region may offer a large and dependable supply of water power, three conditions are necessary: (1) there must be abundant precipitation,[55] (2) stream-flow should be uniform, and (3) there should be sufficient slope or gradient to provide a good head or fall of water.[56] These three conditions are found on the largest scale in Africa, which has 40% of the world's potential water power (see Table 11). Africa is not the largest or the most mountainous continent, but it contains the largest area of high land within the zone of heavy tropical rainfall, and hence the great African rivers, especially the mighty Congo, offer the world's greatest supply of water power. Among the specific power sites of the world, few are as nearly ideal as Niagara Falls, where, with four of the Great Lakes as a giant reservoir, a large and steady volume of water flows through the narrow Niagara River and drops 327 feet through turbines to generate electricity. At power sites where the stream-flow is erratic or the head of water is inadequate, man must spend vast sums of money to build great dams and reservoirs.

Obviously the water-power potentiali-



The four graphs visible on these four pages show some of the problems involved in the proper taming of a river, and harnessing it to our uses.

This one shows the flow of water for one year in the Susquehanna River at Harrisburg. The river has a practically lakeless basin, with much steep land, the greater part with rather poor forest cover.

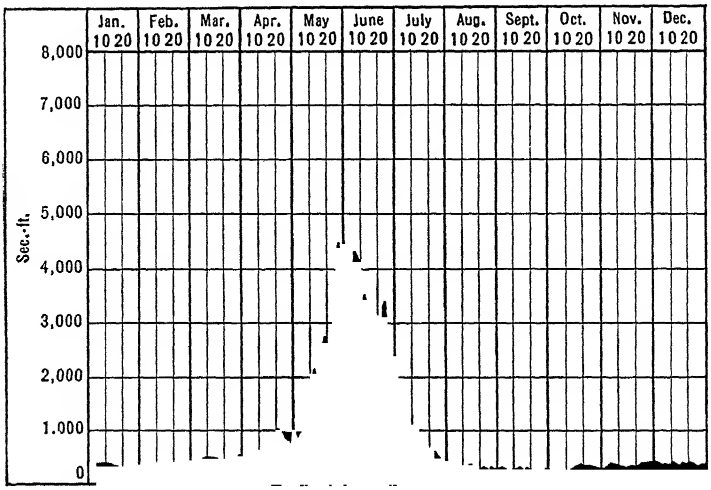
[55] Little precipitation may occur at the power site. Boulder Dam lies in a desert, but the headwaters of the Colorado River are fed by abundant rainfall.

[56] At one time little waterfalls in small streams were prized power sites that could be easily used by the simple water wheel, but today a large volume and big head of water are deemed necessary for use by the modern turbine. The country mill wheels of 1850 have passed into ruin by the thousand in the United States.

tics of a country are affected by many circumstances. If the land is high, like Norway, it may be rich in waterfalls which are so completely absent from flat lands like Netherlands, Denmark, and Florida. The seasonal distribution of the rainfall may give three months' flood and six months' drought in which torrents become dry stream beds, a condition found in monsoon countries and where the Mediterranean type of climate prevails. Here water-power plants may be idle a large part of the year unless there is some kind of water storage.

The water runs away more quickly from hilly than from level land. Even where the rainfall is well distributed throughout the year, there is, in small short streams, a great variation because of the quick running off of the water after rain. A large river system tends to even up these inequalities.

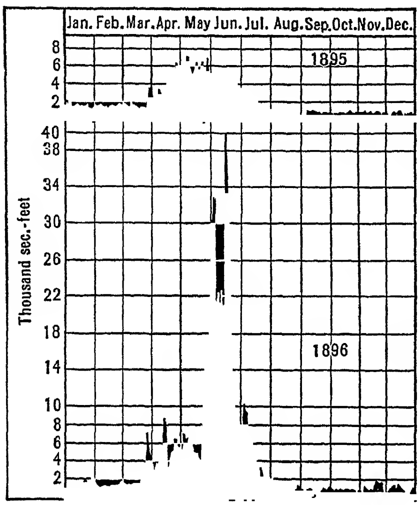
A very important factor affecting water power is some form of natural water storage. The spongy leaf mass of the forest floor holds water and makes more even stream-flow and better water power on the forest stream than on one draining tilled lands or hard-tramped pastures. Porous volcanic soils like those of parts of our Cascade Mountains are splendid. So are swamps and marshes, and lakes are best of all. Man improves streams by building dams to serve as reservoirs and hold the water, but the natural reservoirs of lakes are manyfold better, and hold waters that would otherwise be wasted in freshets, and let it out in time of drought. As most of the world's lakes are due to the action of glaciers, the fact that an elevated region has been glaciated is, granted rainfall, a most important thing in deciding its water-power resources. The St. Lawrence River system is the crowning example of this. The Niagara River with its wonderful natural reservoirs varies but little in volume, while the lakeless



Discharge of water for one year from the Arkansas River, near Canyon, Colorado. This stream, fed by Rocky Mountain snows, has plenty of water for irrigation in June, but very little for August and September, hence the development of great reservoirs in the Rocky Mountains.

Potomac varies according to the amount of rainfall from 1,000 to 250,000 cubic feet per second.

Snow fields and glaciers are second to lakes as natural reservoirs, and they have the particular advantage of releasing the water in time of summer drought and holding it tight in a period of excessive



Discharge of water in cubic feet per second of the Boise River above Boise, Ida., for two successive years. Snowfall does not always duplicate. (Newell, U. S. Geol. Survey.)

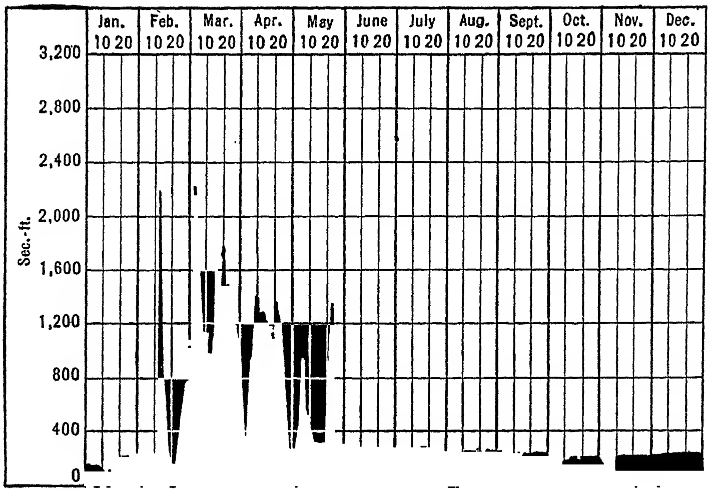
winter precipitation. These factors, combining with a heavy rainfall and the high Coast Range, Cascades, and Sierra Mountains, give the Pacific Coast states nearly the largest potential water-power resources of the United States.

If flood waters were stored so that the streams were more fully utilized, it is estimated that it would be practicable to develop in the United States about 80 million horsepower.

Norway and Sweden have unusual water-power resources in their mountains, glacial lakes, glaciers, and snow fields. They have poor coal supply and in their forests a resource demanding power. It is but natural that they, like the Swiss who have similar conditions, should be leaders in water-power development, as shown by the fact that the Swiss are leading water-power engineers and that water power furnishes two-thirds of all the power used in Sweden and three-fourths of it in Norway.

Temperature also affects a region's supply of water power. In areas that have long and cold winters, as in Siberia, the Yukon Valley, and northern Canada, many a river freezes solid for months. At such times the watercourse breaks out through some weak place and flows along the top of the stream, freezing and piling up great masses of ice and flowing about in devious ways to escape its own obstructions. If the land is fairly level, the water-power supply is dissipated with the icy floods that inundate the countryside. If the stream flows through a narrow gorge, great ice jams are formed that hold back the water. When the thermometer remains at 30, 40, or 50 degrees below zero for weeks at a time, stream-flow is reduced, particularly in the upper course and small tributaries. Extremely cold temperatures for prolonged periods of time resemble drought in power to injure a dependable, year-round water-power supply.

Dry summer lands like the Mediterranean countries and California are greatly handicapped for water power unless they happen to possess mountains where snow fields and glaciers melt in summer and furnish a flow when the rains do not come. Thus, the snow-fed waterfalls of the Alps have been put to use by the Swiss and Italians who have no coal, and the waterfalls of the Sierra Nevada Mountains in California are al-



The discharge of water for one year from the Cobosseecontee, a small river draining many lakes in the Maine woods. Note the differences between it and the lakeless Susquehanna, but even this lake-fed stream presents a great problem for us if we are going to utilize all of its water.

ready harnessed, power being carried to towns and cities in the Great Valley and Los Angeles Basin.

Lands of monsoon rain, like India and other countries of southeastern Asia, have even a worse handicap than the Mediterranean lands, because the dry season comes in winter when snow fields are less effective. No wonder that India should primarily be described as a land of tanks. Therefore, despite its heavy rainfall, its water-power resources are limited.

The tropics have large areas devoid of water power, and here and there resources of stupendous size. The grand prize in water-power creation seems to be the combination of conditions which prevail on the Congo. (See potential resources of French and Belgian Congo, Table 11.) This river runs east and west along the equator in such a position that the doldrum rains fall continually on its northern branches, its sources, or its southern branches, thereby causing it to miss the great seasonal fluctuation common to all great rivers but the Niagara and the Congo's twin, the Amazon. But, unlike the Amazon, the Congo kindly tumbles some 3,000 feet in a series of cataracts near its mouth, making water-power resources so stupendous as to be several fold those of any other continent.

Stanley Falls on the middle Congo with its seven cataracts is estimated to have ten to fifteen million horsepower, but the problem of developing it involves much difficult engineering.

From the plateaus of Central America, streams fed by the trade wind rains develop many fine waterfalls, while from the Andean plateaus streams go down to the interior of South America from the plateaus, which give an unrivaled descent of from 6,000 to 10,000 feet. The plateaus of southern Brazil also result in many extensive waterfalls. Many of these along the coast and the

TABLE 12

Feasible Undeveloped Water Power in the United States, 1938 *

SUMMARY BY REGIONAL GROUPS, UNITED STATES DRAINAGE BASINS

Regional group	Proposed installations: Number of projects	Generating capacity, thousands of kilowatts	Average annual output, millions of kilowatt-hours
New England basins	121	940.0	3,704.9
North Atlantic basins	32	2,114.5	4,508.5
Middle Atlantic basins	97	2,196.3	7,838.0
Southeast basins	63	1,537.9	4,914.5
Tennessee Valley basin	154	4,085.6	14,492.7
Ohio River basin	90	3,987.4	14,766.3
Great Lakes basin	245	2,195.6	12,471.7
Upper Mississippi basin	84	466.4	2,124.5
Missouri basin	52	2,617.1	9,685.4
Southwest Mississippi basin	61	1,366.1	5,754.5
Lower Mississippi basin	12	134.2	712.0
Western Gulf basins	23	132.4	703.6
Colorado River basin	110	4,732.0	26,070.4
The Great Basin	8	52.0	207.1
California basins	249	6,454.5	34,903.3
Pacific Northwest basins	730	19,309.9	130,519.5
Grand total	2,131	52,321.9	273,376.9

SUMMARY BY STATES

Regional group	Proposed installations: Generating capacity, thousands of kilowatts	Average annual output, millions of kilowatt-hours
Alabama	1,238.6	4,285.8
Arizona	2,377.2	12,315.9
Arkansas	581.7	2,255.2
California	6,411.5	34,968.4
Colorado	299.3	2,300.7
Connecticut	116.2	457.6
Delaware	0	0
Florida	0	0
Georgia	817.4	2,617.4
Idaho	2,533.6	19,908.6
Illinois	111.5	516.8
Indiana	249.0	477.0
Iowa	127.1	515.8
Kansas	0	0
Kentucky	792.7	2,855.5
Louisiana	196.4	1,064.0
Maine	364.9	1,608.7
Maryland	728.0	1,834.5
Massachusetts	48.8	137.0
Michigan	267.5	1,014.9
Minnesota	194.2	988.6
Mississippi	127.4	655.3
Missouri	202.5	814.2
Montana	2,481.5	10,283.0
Nebraska	40.2	316.0
Nevada	548.7	2,564.2
New Hampshire	234.4	939.7
New Jersey	113.2	362.5
New Mexico	38.0	250.5
New York	1,845.1	10,892.8
North Carolina	1,144.8	3,898.5
North Dakota	0	0
Ohio	22.3	84.5
Oklahoma	341.9	1,559.4
Oregon	5,152.8	34,487.3
Pennsylvania	1,489.5	2,983.6
Rhode Island	0	0
South Carolina	582.5	2,201.5
South Dakota	13.6	54.6
Tennessee	2,964.8	11,713.6
Texas	254.7	1,048.6
Utah	1,443.5	8,257.0
Vermont	418.1	1,365.5
Virginia	1,366.1	4,481.6
Washington	11,214.4	72,709.0
West Virginia	1,935.0	7,121.5
Wisconsin	210.6	975.9
Wyoming	589.2	2,964.2
District of Columbia	91.5	270.0
Grand total	52,321.9	273,376.9

* The above data summarize the average annual output estimated to be available at the principal undeveloped hydro-electric sites, which have been studied by various public and private agencies and which apparently have economic merit when a need for their power exists.

plateau of São Paulo are being used, but the arrangement of streams causes many of the falls to be in the interior, as the great Iguassú Falls on the Paraná.

It is clear, therefore, that the amount, character, and seasonal distribution of precipitation; the range of temperature; the type and extent of vegetal cover; and topographic, hydrographic, and soil conditions vary greatly among different countries and regions but that each of these factors has an important effect upon the potential supply of water power

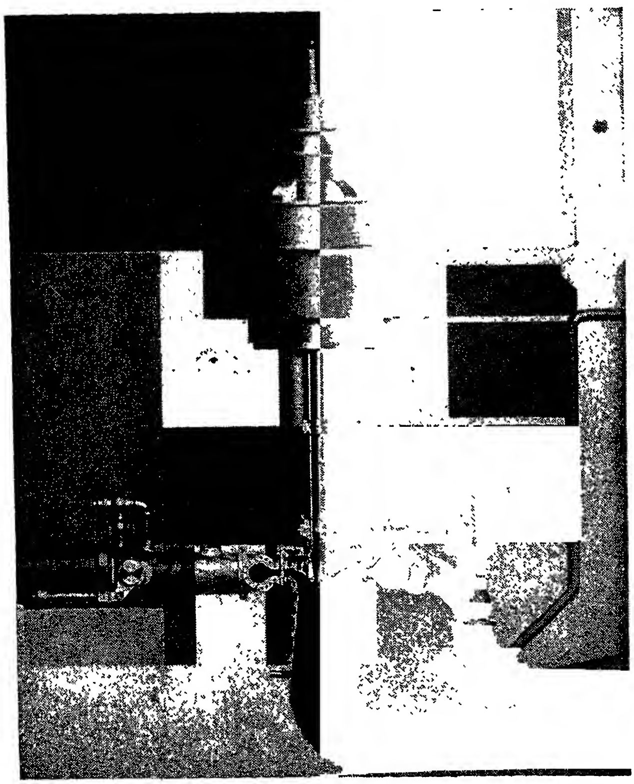
16. *The Development of Water Power*

Early Development in the United States. The use of water power has had its ups and downs, depending on industrial conditions and inventions. It was a factor of great importance in the American Colonies, furnishing as it did a means to grind their flour and saw their logs. Largely because of its splendid water-power resources, New England became the cradle of the Industrial Revolution in America. Factories using the new power-driven machinery developed and thrived alongside the waterfalls of New England, the Mohawk Valley, the Fall Line, and other propitious water-power sites. Indeed, as late as 1869 one-half of all the power used by American industries was water power. As the steam engine invaded American industry, the old-fashioned overshot water wheels so common from 1800 to 1850 were largely displaced in the latter half of the nineteenth century by improved engines and cheap coal.

This dam at Mormon Flats, Arizona, shows the ideal type of set-up—a narrow gorge where the concrete may fit into the living rock and the dam may be both high and short, but it needs a widened valley above it and often has it.

Small country mills were abandoned by the thousands as a result of this change, and in 1900, of the total energy obtained from the mineral fuels and water power, 89% was derived from coal.

Revolutionary Improvements. With the perfection of the steel-reinforced concrete dam, the hydraulic turbine, and the dynamo, water-power development throughout the world entered a new epoch. The use of Portland cement in the construction of dams not only increased the height of fall, or head of water, at a given site but also made possible the storage of water during periods of heavy rainfall for later use in times of drought, thereby reducing the handicap of erratic stream-flow. Furthermore, the construction of giant dams and reservoirs has often increased several fold the amount of water available from natural stream-flow at particular power sites.[57] The modern hydraulic turbine,

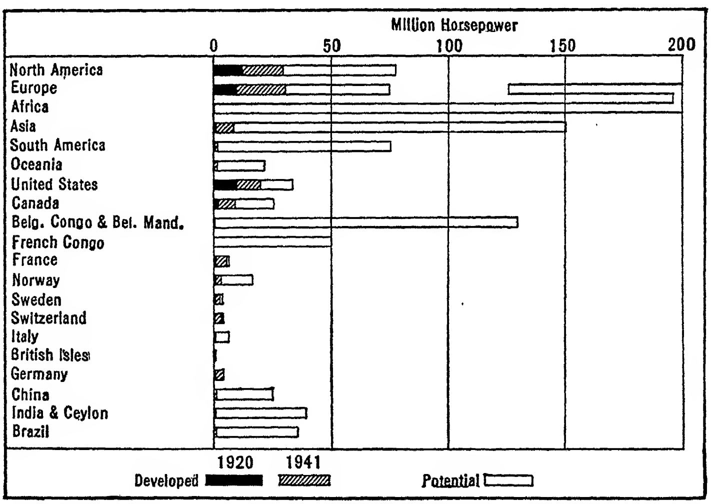


Hydraulic turbine, with a capacity of 39,000 horsepower, a head of 1,028 feet, and a speed of 600 r.p.m. The large upper part is a housing for the whirling dynamo that turns the water power into electricity. A very small wheel receiving water from the pipe under very high pressure whirls at the bottom of the vertical shaft and the water goes away through the large pipe at lower right. Note the size of the man at the right.

[57] Storage provided by the high dam at Grand Coulee made available 6.8 times as much power as could be obtained from natural stream-flow.—National Resources Committee, *op. cit.*, p. 238.

using the great pressure of water dropping through penstocks, or large pipes, has made possible the utilization of any volume of water and a fall of almost any height, thereby making available for power production such great waterfalls as Niagara. The dynamo, turned by a shaft rotated by water flowing through the turbine, generates electricity which can be transmitted several hundred miles, thereby liberating the power consumer from the necessity of locating his factory or mill at the power site.[58] The significance of these three great technological improvements to our water-power industry is evidenced by the fact that the installed water power in this country has increased from 1.8 million horsepower in 1900 to 9.8 millions in 1920, and to 19.8 millions in 1942.

While the water-power industry was revolutionized by the advent of the concrete dam, hydraulic turbine, and dynamo, other improvements have added greatly to its efficiency. It was soon discovered that a large central generating plant can produce electric energy for a given area far more cheaply than a number of small private plants, and this gave rise to a separate power industry selling electricity to ever increasing numbers of industrial and domestic consumers. Again, it was found that many advantages are to be derived from interconnection of many central generating stations, including both hydro-electric and steam plants, which helps to reduce the cost of electricity and to increase the reliability of service. The most efficient plants can be operated full time, the less efficient plants being called into service to meet peak demands. When a severe drought or seasonal water shortage occurs, causing a curtailment or cessation



If all countries did as Italy, Germany and the British Isles have done, this graph would be very different. These three European countries have water-power plants whose capacity exceeds potential water power, based on ordinary minimum flow.

[58] *Cf. supra*, p. 54.

of hydro-electric production, power can be supplied from more fortunate areas.[59] Again, interconnection provides insurance against the inconvenience caused by the accidental breakdown of any plant belonging to the system, for the stricken plant can draw upon outside power. Then, too, the interconnection of hydro-electric and steam plants makes possible a more frugal use of coal, oil, and gas in electric power production, at least in those areas where mineral fuels are more expensive. Finally, it may be noted that a super-power system, pooling the resources of many generating plants, often serves a large area involving a diversity of consumers. Since the bulk of the industrial demand comes in the daytime and since domestic consumers use most electricity for light at night, a diversified demand permits a fuller use of generating facilities throughout the 24 hours of each day.

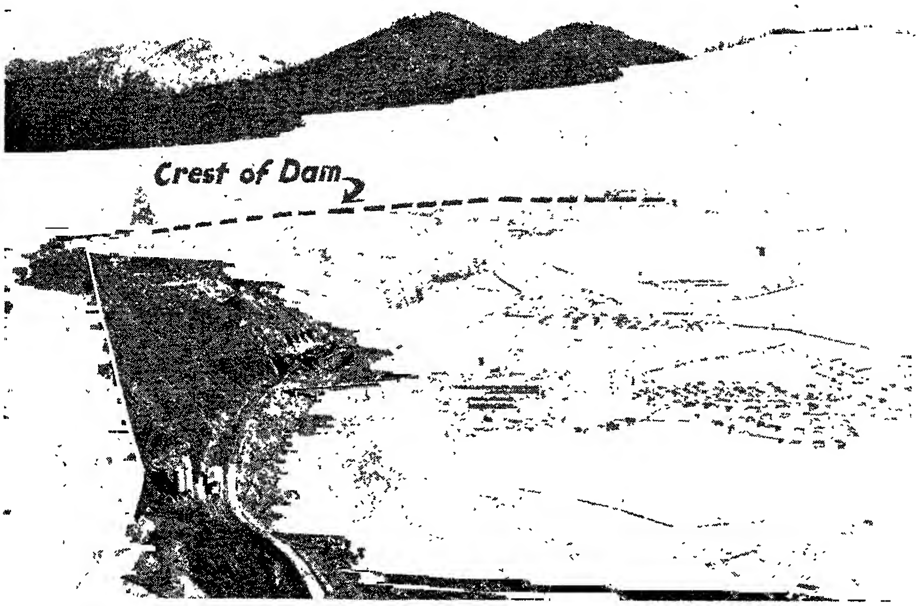
Since World War I there has been a widespread development of super-power systems in this country. The greatest progress has been made in New England, Pennsylvania and New Jersey, the South Atlantic states, the Pittsburgh-Ohio industrial area, the Chicago district, and in California and Washington, yet in none of these areas are obtained the maximum benefits that might be derived from a high degree of interconnection. Much progress remains to be made.

Today large blocks of power, ranging up to 287,000 volts, are transmitted economically over a radius of 250 to 300 miles. Indeed, it is conceivable that one large centrally located plant could serve a circular area of at least 200,000 square miles, or an area twice the combined size of New York, Pennsylvania, and New Jersey, or a region three times as large as New England. Every improvement in transmission technique is of special importance to the hydro-plant, which must generate its electricity at the water-power site.

Economic Factors Affecting Development. Whether potential water-power resources will be developed or not in a given area depends largely upon two economic considerations, namely, (1) the present and estimated future market demand for power and (2) the present and future competition from other fuels.[60] These two economic factors go far to explain the present distribution of the world's developed water power (see Table 11). The great bulk of the world's water power has been developed to date by private enterprise, whose sole aim is to reap the maximum profit. In the case of governmental enterprise, the profit motive is not dominant or may not even exist. The government is able to wait a long time for a return on its investment and is able to take a chance that a future market for power will arise after the facilities of power production have been created. Indeed, the market demand for power may not be the sole or major consideration, as the government may wish to provide the people with such services as irrigation, navigation, and flood control which often require large-scale re-

[59] In northern Italy, around Genoa, an interconnected system of hydro-electric plants secures its power chiefly from the Alps in the summer and fall, when Alpine snow and ice are melting, and chiefly from the Apennine Mountains in winter and spring, when the Italian Peninsula receives its maximum rainfall.—Erich W. Zimmermann, *op. cit.*, pp. 550-551.

[60] See *ibid.*, pp. 545-550.



The Shasta Dam. This picture of the foundation of the Shasta Dam and the dotted line showing where the crest will be gives us some inkling of the vastness of enterprises that involve control and effective utilization of a river—also excellent chance to consider the economic doctrine of diminishing returns. Can the increased cost of the complete storage of water be paid for by possible returns?

This dam was six years in building. It reached the maximum number of men at work—namely 3,704, in the third year.

In the left foreground we see piles of broken rock, silos for cement. The long white thing is a part of the belt conveyor system of which there was a total of 10.8 miles in connection with the enterprise. At the height of activity, the conveyors handled 1,100 tons of material per hour.

Six million barrels of cement were used, special plant was built to make it, many miles of highway were built to service the enterprise and a temporary town for the workers. 4,500,000 acre feet of water will be stored and the ultimate capacity of the power plant at its base will be 379,000 kilowatts.

This dam, built for flood control, irrigation water, navigation water, power for various purposes, including lifting some of its own water so that it may flow over land to be irrigated. It is plain that our psychology is such that it will not permit such an enterprise to be built by a private corporation. Hence the new type of organization—an *authority* of which the Tennessee Valley Authority is an example, also the Port of New York Authority, and this Sacramento Valley enterprise.

forestation and soil conservation programs. Obviously, the government is better able to develop the entire water resources of a river basin than any private corporation. It is scarcely conceivable that private enterprise could ever have undertaken such gigantic projects as T.V.A., Boulder Dam, Grand Coulee, and Bonneville, and history will probably record that they were well worth the cost. Throughout the world governmental projects are steadily increasing. While the government is not bound by short-run monetary calculations, it is or should be interested that each project, considered in view of all services rendered, will yield during the life of the project an adequate return to the people

on the investment of taxpayers' money. In planning a project, the government must consider present and future market demands and the availability of competitive fuels, for these two factors determine the economic practicability of all water-power development.

Distribution of Water-power Development. As the data in Table 11 indicate, the greatest development of water power has occurred in Europe and North America. Each continent has only about 11% of the world's potential supply, and each has approximately 42% of the world's developed power. Italy, Norway, Switzerland, and Sweden together possess about one-half of the developed horsepower of Europe, Norway leading the world in output of electric energy per capita.[61] Each of these countries is virtually destitute of mineral fuels, and each has a well-developed industrial demand for power. The most intensive use of available water-power resources is found in Germany and Italy, the installed capacity of turbines and water wheels exceeding the potential power available under conditions of minimum stream-flow.[62] The leading manufacturing nations of Europe, however, are Great Britain, Germany, Russia, and France, which are the greatest producers of coal, and each depends predominantly upon coal as a source of energy. In Great Britain, where coal is plentiful and potential water-power resources are comparatively small, hydro-electric projects are of limited importance. In Germany the huge industrial demand for power has led to an intensive use of all available power resources, including coal, lignite, and water power. Russia, an industrial newcomer that is rich in coal, oil, gas, and water power, had only begun to utilize her water-power resources prior to the outbreak of World War II. France makes great use of water power, since nearly one-third of her annual coal supply must be imported. The demand for power in the highly industrialized and urbanized sections of western Europe is tremendous, and in those countries lacking mineral fuels water power plays its most important role.

In North America the greatest development of water power has occurred in eastern United States and the southern parts of Quebec and Ontario in Canada, for, as in western Europe, here are to be found the greatest density of population, development of manufacturing, and demand for power. The most intensive use of water power is in New England,[63] where manufacturing began with the use of water power long before the steam engine invaded American factories. Like Italy, New England has long been dependent upon imported coal to meet the bulk of her power requirements. In coal-poor Quebec and Ontario, as in Norway and Sweden, great pulp and paper and huge electrochemical industries have been devel-

[61] In 1936 the production of electric energy per capita in kilowatt-hours was: Norway 2,758, Canada 2,037, Switzerland 1,450, Sweden 1,181, and the United States 868.—U. S. Dept. of Commerce, *Foreign Commerce Yearbook, 1938,* Washington, 1939, p. 413.

[62] The storage of water behind great dams makes it possible for many hydro-electric plants to have and to use an installed capacity two or three times larger than the amount of power existing under conditions of minimum stream-flow, or the power naturally available 95% of the time.

[63] In 1941 the installed capacity of New England turbines and water wheels amounted to 1,977,000 horsepower, whereas the potential water power available 90% of the time amounted to 988,000 horsepower.

ment of water power in Europe and North America, the water power of the other continents is little used. Three-fourths of the developed horsepower of Asia are to be found in tiny, industrialized, mineral-poor Japan, and about three-fourths of the developed power of South America is consumed by the infant industries of Brazil, especially around São Paulo and Rio de Janeiro. The colossal potential resources of Africa are virtually unused. It is unfortunate that so much of the world's potential water power lies so far away from population centers and markets. For a long time to come it is likely that the great bulk of the world's water power will continue to flow away to sea unused by man.

11. Other Sources of Power

The Wind and the Tide. Fortunately man does not have to depend for power upon wood, coal, oil, natural gas, or waterfalls. These are but a very small fraction of a veritable fury of power manifestations in the midst of which man lives. The most promising next rival is perhaps the wind. New types of generators are about ten times as efficient as the old windmill which distributed water on the farms. It is a fact that if the propeller of the ocean steamer goes too fast it kicks the water out of the way, makes a hole and then runs fruitlessly in the hole. Something of the same sort seems to occur with the widely distributed multi-vaned windmill, with many rays filling its complete circle. An airplane propeller has just two, which apparently always find air to kick at any point in their revolution. The new windmill is of this type. Hundreds of European engineers have been working upon it fiercely since World War I. The idea seemed to be like this: fields of great mills, each with arms perhaps fifty feet or more in length, each with a dynamo directly attached to its shaft, these fields in windy places such as the top of the southern Appalachians, the top of the White Mountains, the shores of the Great Lakes, windy Cape Cod, all harnessed into one system. When the wind stops in one or two places, it would most likely be blowing in others, thus reducing power storage to a minimum.

The rotor, working on the same mechanical principle that makes the baseball curve, has shown great promise as the possible ultimate device for catching the power of wind. Thus far no one has come forward with the heavy expense money required for extensive experimentation. Authorities, seemingly competent, praise the device. Perhaps the Russians will do it for us.

The cosmic force of gravitation and planetary momentum gives us the tides. This we have thus far used but little, although methods for its utilization have been perfected.

The English have already impounded several square miles of high tide, twenty feet high, in the estuary of the Severn, south of Wales, and propose to do the same in the estuary of the Dee, north of Wales. As these high tides are three hours apart, and as the water is made to work as it goes into tidal basins and out of them, the prospect of almost continuous power is an important aspect of the enterprise. But the tide cannot be ex-

pected to solve any major part of man's power needs.

Volcanic Heat, the Sun, and Other Sources. Another cosmic power source of considerable promise is earth heat, especially around areas of volcanic energy, active or latent, as evidenced by hot springs. This source of heat is being used to run steam engines, electric generators and do industrial service, in Tuscany, Italy, in California, and in Iceland.

The heat of deep earth is worthy of consideration in this connection.

The chief source of all our power is the sun, whose energy is stored in wood and fossil fuels, but whose chief manifestation is in the wind. This result of the unequal heating of the earth's surface develops such tremendous energy that in the work of carrying the earth's waters through the air it uses power of which the water-power resources as man sees them are but a small fraction of 1%. In passing over the surface of the sea the wind raises the waves which have eaten away continents. In the mere rising and falling 2 feet three times per minute the waves exert on a strip 100 feet wide 6,000 horsepower per mile. This power man has not yet utilized.

We can boil ether and probably other cheap chemicals by subjecting them to the heat of ocean water at a temperature of 80°. We can condense it by subjecting it to cold water at a temperature of 40°. It so happens that there are millions of square miles of tropical ocean surface with the above high temperature, while a half mile below are limitless cubic miles of water with the requisite low temperature—the one fed by tropic sunshine and the other by Arctic chill whose cold waters fill all deep seas and are continuously replenished by both Polar zones.

This offers interesting power castles to the engineer who observes that many West Indian islands have both kinds of water within a mile of the surf, and experiments have been made by Georges Claude along the coast of Cuba.

All other sources of power pale beside the great source—the direct rays of the sun which are calculated to hurl into 9,000 square miles of Egypt enough power to replace all the engines and water wheels in the world. Three different types of mechanism have utilized this power to a small extent. The success of such power development to the point of superiority to existing power sources offers interesting speculation as to where would be natural seats of empire when the best sources of power were within the zone of 200- or 400-mile power transmission from cloudless deserts.

According to Charles G. Abbot, long-time specialist in the study of the sun (see Report of Smithsonian Institution, 1944, page 119), the earth "receives all the time from the sun the heat equivalent to one-quarter of a quadrillion horsepower" (250,000,000,000,000). That figures out to one horsepower for every 5 square feet of the land surface of our terrestrial globe. That number of flesh and bone horses could not stand upon the earth. We should be able to salvage more of this heat than we do.

Alcohol is, however, nearer to us from the mechanical standpoint. It can be produced from grain, sugar cane, henequen pulp, corn stalks, potatoes, and a great variety of vegetable materials. We already know how to use it as a rival

of gasoline and kerosene, and it is extensively used for those purposes in Germany, which has almost no petroleum and much potato land. Alcohol as a source of power permits us to go on indefinitely, because it depends upon agriculture, the enduring industry. The alcohol tank steamer coming from a distillery on a trade wind shore beside tropic yam or cane fields could probably give us a surprisingly close duplicate for many of the products of petroleum.

New chemical discoveries may give us any day cheap liquid fuel that will turn the whole power world topsy turvy.

The prediction that our coal will never all be mined is therefore not altogether fantastic, but the last coal may be worth $100 a ton, present prices, because of some irreplaceable by-product.

. . . 6

Iron and Steel: The Backbone of Modern Industry

1. *The Role of Iron and Steel Today*

The Age of Iron and Steel. The modern Machine Age in which we live is essentially an age of iron and steel. Because of its hardness, strength, and durability, because of the ease with which it can be cast and worked into any desired shape, and because of its remarkable cheapness under modern methods of production, iron is the most important and widely used metal in the service of man today. Chiefly from iron and steel are made the engines and machinery that harness the tremendous power derived from the mineral fuels and falling water. From iron and steel are created a multitude of machines that have done so much to increase the effectiveness of human labor—machines that transform raw materials into myriads of products wanted by mankind, machines that convey men and goods and ideas, machines that plow and sow and reap, machines that drill, dig, construct, control, calculate, and almost think, and machines that are used to produce more machines. Without the power-driven machine, the work of the world would again depend primarily upon the muscle of man and beast. Without iron and steel, the mechanized civilization of the present day would not exist, and we would surely starve by millions in a month or two.

Whereas the energy that keeps modern industry in motion is derived chiefly from coal, the sturdy backbone that supports all industrial development is made of iron and steel. Only those nations that possess or have easy access to large supplies of coal and iron and only those with a well-developed iron and steel industry have achieved outstanding industrial progress and great wealth and political power in modern times. These nations, too, are the leading military powers, for steel is the greatest of all sinews of war. Verily, coal and iron are the twin pillars of physical strength underlying the civilization of today.

Chief Uses. Iron was a semi-luxury, and steel was an expensive one little more than a century ago, but as a result of greatly improved large-scale production methods they have come to be cheap and versatile products in the universal service of man. Steel is merely iron that has been hardened and given desirable qualities by the addition of carbon and other alloys. Its prime function today is to serve as a raw material in the production of durable goods that will withstand great stress and strain and also the shock, wear, and tear of re-

peated use. From this strong and durable material are made the heavy machinery and equipment needed in vast quantity and variety by the construction industry, transportation, mining, and virtually every form of manufacturing, including the steel industry itself. The I-beams and structural supports of buildings, the ships, bridges, pipe lines, rails, locomotives, railway cars, automobiles, airplanes, mining equipment, and countless factory machines now in service throughout the world all had their origin in the great plants that fabricate steel.

By alloying iron with small amounts of other metals, steel can now be made hard or soft, tough or brittle, pliable or rigid to meet the varied demands of modern industry. Probably 90% of the world's iron is now converted into steel. Furthermore, it should be noted that iron has unusual magnetic qualities which make it indispensable to the electrical industry, where it is used in the manufacture of dynamos, motors, telephones, telegraph instruments, radios, and other electrical equipment.

In the United States, where huge distances require tremendous transportation facilities, the total amount of steel used for all transportation purposes is in normal years over a third of our entire output (see Table 13). About 16% to 20% of our steel output is needed by the construction industry, whereas only a small portion is devoted to the production of non-durable consumers' goods, such as tin cans and other metal containers that are used but once.[1] So great has been the growth of the American steel industry that today the use of steel in this country amounts to about a thousand pounds per capita per year as compared with the use of one-half of a pound of wrought iron at the time George Washington was inaugurated as our first President.[2] Throughout the United

TABLE 13

PERCENTAGE DISTRIBUTION OF HOT-ROLLED IRON AND STEEL PRODUCTION AMONG MAJOR CONSUMING INDUSTRIES IN THE UNITED STATES

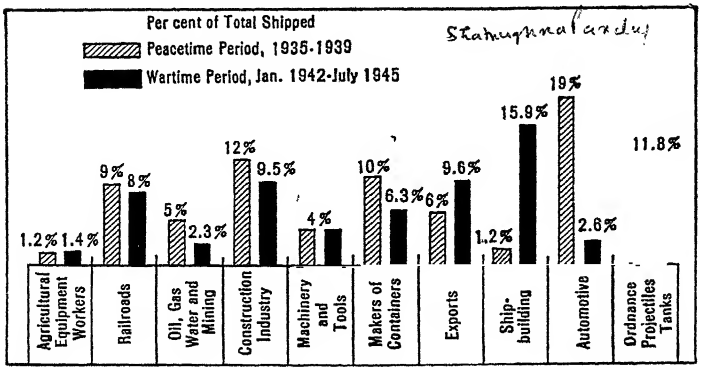
Industry	*1926–31 average*	*1932–38 average*	*1938*
Automotive	16.3	20.8	17.3
Construction	19.9	16.0	18.8
Railroads	17.9	10.1	6.1
Container	4.7	8.4	9.1
Agriculture	6.0	6.0	4.7
Oil, gas, and water	8.3	6.0	7.4
Exports	5.9	5.5	7.5
Machinery	3.8	4.2	3.5
Furniture and furnishings	*	3.6	3.6
Shipbuilding	0.9	0.9	1.6
Mining	0.7	0.5	0.3
Miscellaneous	15.6*	18.0	20.1
Total	100.0	100.0	100.0

* During 1926-31 "Miscellaneous" includes "Furniture and Furnishings."

Source: United States Steel Corpn., *United States Steel Corporation T.N.E.C. Papers*, vol. 1, New York, 1940, p. 380.

[1] In recent years much more steel has been used in the production of durable consumers' goods such as automobiles, household appliances, refrigerators, air-conditioning units, stoves, etc.—United States Steel Corp., *United States Steel Corporation T. N. E. C. Papers*, vol. 1, New York, 1940, p. 380. During the war year of 1942, 16% of the steel output was used for shipbuilding, 14% by the construction industry, 7% by railroads, 6% for containers, 4% for machinery and tools, and 3½% for automobiles and aircraft.—American Iron & Steel Institute, *Steel Facts*, No. 59, April, 1943, p. 3.

[2] United States Steel Corpn., *A Pictorial Presentation of a Basic Industry*, New York, 1939, p. 3.



This graph gives interesting facts as to the effect of the war effort, World War II, on the steel industry.

States there are now more than one billion tons of steel in use.

2. *The Formation, Distribution, and Mining of Iron Ore*

Formation of Iron Ore. Iron, the most useful, is also one of the most universal of metals. It exists practically everywhere throughout the earth's crust and is responsible for the red color of clay banks and even of our own blood. While iron ores are plentiful, the metal is never found even in a reasonably pure state except in recently fallen meteorites. It is dissolved from almost every hillside by the leaching rain waters, and where a stream of water with iron in solution enters a stream of water with lime in solution, iron ore is deposited. For this reason we have a string of iron deposits in the United States from northern Vermont to central Alabama. They are scattered along the edges of the limestones which are so common throughout this whole region, especially in the Great Valley from Lebanon, Pennsylvania, to Chattanooga, Tennessee, which has many deposits of limestone throughout its extent.

Sometimes iron streams flow into small lakes, where lime or certain organisms cause the deposit of the ore in a powder upon the bottom, the so-called bog ore which has at times been quite an important source of the world's iron industry. Bog ore is sometimes collected at intervals as a kind of harvest on lake bottoms in Sweden, but the yield from such sources is insignificant. The principal iron ores in use today are hematite, a red or gray iron oxide which is by far the leading source of iron; magnetite, a black, magnetic iron oxide; limonite, a brown, hydrous iron oxide; and siderite, or iron carbonate. Hematite, limonite, and siderite are sedimentary or residual ores, as they were either deposited as sediments at the time of the formation of the surrounding rock or were residual deposits of iron that were left when other materials had eroded or washed away, whereas magnetite is a primary ore that was formed with igneous rock. Where the conditions suitable for the deposit of iron ore continue undisturbed for great periods of time, we have large deposits, veritable mountains of ore,

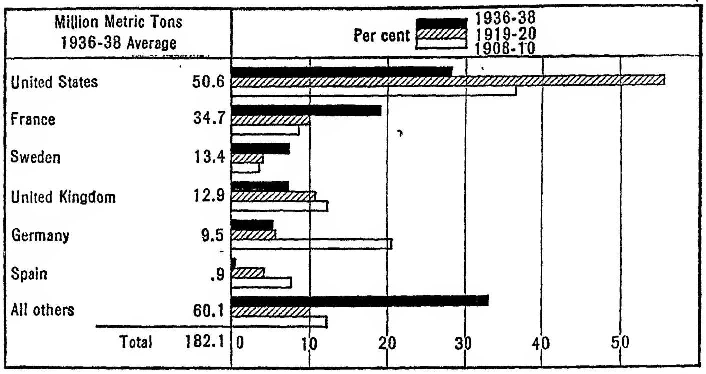
such as exist in the rough country south and west of Lake Superior, in the mountains of Durango, Mexico, the mountains near Santiago, Cuba, near Itabira, Brazil, in the Cantabrians of northern Spain, in northern Sweden, at Magnitnaya ("Magnetic Mountain") on the eastern slope of the Urals, and in certain other parts of the world.

Economic Availability of Iron Deposits. Whether or not it is profitable to exploit a given iron deposit depends largely upon its richness, purity, physical accessibility, size, and general location. Very little iron ore is mined in the world today that contains less than 30% of iron.[3] In the United States, which is fortunate in having large and rich deposits, nearly all of the ore that is mined has an iron content of more than 50%. All iron ores contain some impurities, such as oxygen, silica, alumina, lime, magnesium, sulfur, arsenic, titanium, and phosphorus. Some of these, especially sulfur, titanium and phosphorus, are objectionable, since they tend to weaken iron, and for a long time they were difficult or expensive to remove in iron and steel making. Indeed, it was not until 1878 that new processes made phosphoric iron ores available for use. The desirability of an iron deposit is also affected by its geological formation and physical accessibility. Open-pit operations are obviously much cheaper than shaft mining, and many a deposit of lesser richness and purity is used because it lies near the surface. Over half of the world's iron ore is now mined with open-pit methods.

While the relatively small demand for iron a century and a half ago could be easily supplied from a large number of small and scattered deposits, the great demand for steel in recent times has led to the concentration of mining operations on those deposits with large reserves adequate to support large-scale production for a long period of time. Hence, many a small deposit of superior richness and purity has been abandoned. Finally, it should be noted that since iron ore is so heavy and bulky in proportion to its value, it cannot be moved very far in large quantities unless cheap transportation is available. Since modern methods of iron and steel manufacture can utilize iron ores that vary greatly in richness and purity, those large deposits that are located near the market or near cheap water transportation are utilized most intensively. The greatest markets for iron ore are the large industrial areas that have arisen in or near the world's great coal fields. Here are to be found the coal and coke that are indispensable to the making of iron and steel and thus supply a great demand for iron and steel products.

Distribution of Iron Mining. Although iron is more widely distributed throughout the earth's crust than any metal except aluminum and although some 45 countries are engaged in mining iron ore, we find that more than

[3] The world's richest deposits of iron ore are the hematite ore of the Iron Knob district in southern Australia, with an iron content of 68.7%; the hematite near Krivoi Rog in southern Russia, with 68.5%; the hematite at Itabira, Minas Geraes, Brazil, with 68.2%; the hematite at El Tofo, near Coquimbo, Chile, with 67.5%; and the magnetite of the Kiirunavaara district in northern Sweden, with 67.7%.—Olin R. Kuhn, "World's Iron Ore Reserves Now Exceed 57,000,000,000 Tons," *Engineering and Mining Journal*, vol. 122, July 17, 1926, p. 85. The maximum percentage of metallic iron found in magnetite is 72.4%; in hematite, 70.0%; in limonite, 59.9%; and in siderite, 48.3%.



This graph of world iron ore production shows by its percentages the spread of the industry to countries other than those here shown. A change of boundary, 1918, explains most of the French-German difference.

85% of the world's iron ore is mined each year in the United States, France, Russia, Sweden, Great Britain, Germany, and Belgium-Luxemburg.[4] All of these countries except Sweden have important coal deposits and great industrial markets. Sweden, having no coal, must export about 90% of her iron ore. The other six countries manufacture about 85% of the world's steel.

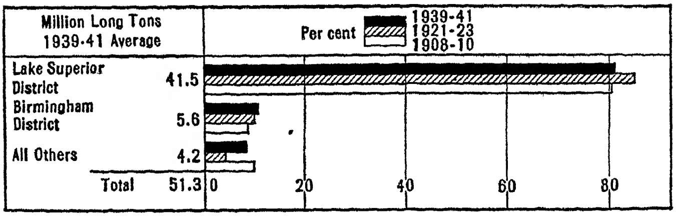
In contrast with the scattered, small-scale production of iron ore little more than a century ago, the mining of iron ore today is a large-scale enterprise that is dominated by gigantic corporations and cartels which frequently control all the steps in production from the time that iron ore is removed from the earth until the finished or semi-finished products of steel are delivered to the consumer.[5] Under the financial control of these modern, industrial behemoths are iron mines, coal mines, limestone quarries, steamship lines, coke ovens, blast furnaces, steel works, rolling mills, forge shops, foundries, and various fabricating shops.[6] With an eye to the future supply of iron, some of these huge American and European concerns have made large investments in iron ore reserves overseas.

The mining of iron is typical of all mining industries, which, in contrast to agriculture, are always temporary. At best, the digging of a mineral is the removal of the accumulation of ages, which when once removed is gone forever. The Germans call it "The Robber Industry." The life of a mining town is therefore temporary and uncertain. Such towns rise and fall, or change the source of their support, while an agricultural community may live on undisturbed, tilling the same fields for three

[4] Since 1922 Luxemburg and Belgium have been linked together in a customs union with no tariff barriers between them. Prior to World War I, Luxemburg was linked similarly with Germany.

[5] In the United States 18 such fully integrated companies control 91% of the nation's steel-making capacity.—Evan B. Alderfer and Herman E. Michl, *Economics of American Industry,* McGraw-Hill Book Co., Inc., New York, 1942, p. 29. Also see Ervin Hexner, *The International Steel Cartel,* The University of North Carolina Press, Chapel Hill, N. C., 1943.

[6] The Bessemer & Lake Erie R. R. Co., connecting the lake port of Conneaut, Ohio, with Pittsburgh, ranks second only to the Pennsylvania R. R. in the carriage of iron ore; it is a subsidiary of the United States Steel Corpn.—U. S. Tariff Commission, *Iron and Steel,* Report No. 128, Second Series, Washington, 1938, p. 317.



This graph of United States iron ore production raises an interesting question: "Where would we be industrially without the Lake Superior ore district?"

or four thousand years, as in parts of China, and the field may even be the better for it. The iron manufacturing industry especially has roamed from place to place as changed conditions in manufacture, industry, and commerce have made it profitable or unprofitable. It does not depend on ore alone. There must be fuel, labor, and markets, a combination of factors. A change in any one factor may upset this industry as it does so many other industries.

3. The Early Development of Iron Manufacturing

Ancient Iron Manufacture. Iron was first used by man long before the dawn of history, its use generally following that of copper and bronze. Archaeological excavations have uncovered not only tools, weapons, and other articles wrought of iron but also the remains of crude furnaces on the sites of ancient civilizations in Egypt, China, India, Chaldea, and the East Indies. In the Egyptian pyramid of Cheops was found an iron wedge, probably placed there about 3000 B.C., which now reposes in the British Museum in London. The iron manufacturing industry of ancient times reached its zenith under the Roman Empire and was located chiefly in Italy, Spain, Belgium, and Britain. There was a considerable international trade in both iron ore and its products, but iron was a luxury far more expensive than copper. The chief use of iron was in the manufacture of armor and implements of war, which during the later years of the Empire was taken over by the government and concentrated in large factories owned by the state.[7]

From prehistoric times until the fourteenth century A.D., the technology of iron making remained virtually unchanged.

The Catalan Forge. Iron is extracted from the ores by burning off the impurities, the chief of which is oxygen. No ordinary fire will make sufficient heat, but prehistoric man learned how to make a super-heated fire probably by the means still in use very recently in so many parts of the world by peoples with primitive industry, as in interior China or central Africa. A hearth or forge was made with an artificial draught worked by bellows driven by hand or foot or occasionally by the force of a prevailing wind focused through a funnel so that the fire got hot enough to reduce the

[7] See Meredith Givens, "Iron and Steel Industry," *Encyclopaedia of the Social Sciences*, vol. 8, The Macmillan Co., New York, 1932, pp. 297-298, and Tenney Frank, *An Economic History of Rome*, The Johns Hopkins Press, Baltimore, 1927, pp. 231-236.

iron to a sticky mass, or bloom, in the bottom of the fire. This was purified by reheating and hammering, and it made a metal the *quality* of which has never been excelled. These forges, like the hand loom, were pretty much alike the world over, and commonly bear the name of Catalan forge, after the Spanish province of Catalonia. The universal fuel for this forge was wood charcoal. Only the best ores could be used, and this industry was naturally dependent upon the combination of ore and forest in the same place. This type of apparatus made the world's iron for at least 2,000 years and probably much longer. While good, wrought iron was costly, so costly that medieval builders climbed up and dug out of the solid rock of the Coliseum at Rome the links of iron with which the Romans had fastened the stones together. The refuse of medieval and Roman iron makers was long ago used up as good scrap by later British manufacturers.

The Blast Furnace. Toward the end of the medieval period, the stacks of the forges were made taller, and the draught was made stronger, until finally the blast furnace was developed in Belgium about 1340. This new device melted the iron ore into a liquid which absorbed impurities and was poorer iron than the more expensive product of the old forges, but it could be run off into molds for cooling in convenient forms. This cast iron, or pig iron as it was later called, has to be purified before it has qualities other than weight and brittle strength. The blast furnace, like many later inventions, sacrificed quality for quantity and cheapness. The blast furnace was gradually improved by the Belgians, Germans, and French and proved to be much more economical than the Catalan forge in the use of fuel, ore, and labor. By the middle of the sixteenth century, bellows were worked in Germany by cams on the axles of water wheels, as were heavy hammers for the purification of the metal.[8] At this time the large demand for cannon cast from iron greatly stimulated iron manufacturing. It was from Germany that England obtained the blast furnace and other improved methods of iron making.

4. *The Rise of the British and American Iron Manufacturing Industries*

Early Developments in Great Britain. The fuel of the early blast furnace, like that of the forge it succeeded, was charcoal, and the iron industry in England came into disrepute in Queen Elizabeth's time and was subjected to restrictive legislation, because it devoured so much wood that, to keep itself going, it followed the vanishing forests of England from place to place. In the eighteenth century English iron output declined, and it seemed that the English iron industry was doomed because of the limitation of the fuel. There was large iron import from the pine forest districts of Germany, imports from the new American colonies across the Atlantic had begun, and the basis for a great trade was visible between the forested colonies with abundant charcoal material and the bare mother country. But this trade was shattered by a num-

[8] See J. Russell Smith, *The Story of Iron and Steel*, D. Appleton & Co., New York, 1920, p. 25.

ber of improvements in the technology of iron manufacture. One was the substitution of coke for charcoal. As early as 1709 Abraham Darby established the commercial use of coke in smelting, but it was not until sixty years later that coke came into general use, in spite of Britain's need for a better and more abundant fuel.[9] As long as charcoal was used, the size of the blast furnace was limited, because it was impossible to pile up a charge of iron ore and charcoal very high, as the weight of the iron would crush the soft charcoal and smother the fire. By removing this limitation, the use of coke helped to make possible the manufacture of iron on a larger scale. However, the only way that the pig iron of the blast furnace could be formed into useful articles was by pouring the liquid iron into molds of the desired shape, and the finished products were brittle. In 1784 Henry Cort perfected the puddling furnace, heated by coal, which removed most of the carbon from the pig iron, thereby making it malleable.[10] The product, puddled wrought iron, was processed in a rolling mill and shaped for many uses. Thus, pig iron acquired greater utility, and between 1784 and 1830 the puddling furnace was so improved that its output was increased from 10 to 200 tons per week.[11] The old-fashioned bellows of blast furnaces were replaced by improved blowing apparatus, which was first operated by steam in 1790. These and other improvements liberated iron manufacture from the tyranny of charcoal and water power, thereby facilitating a great increase in output.[12] Hence, the British iron manufacturing industry received a new lease on life and prospered greatly during the growth of the factory system in the early nineteenth century when no other country had industrial access to such resources of fuel, ore, and labor.

In the middle of the nineteenth century, the railroad, the steamship, the modern factory with its great use of machinery, caused a rapid increase in the demand for iron, and Britain with her good resources of coal and iron ore lying side by side became the world's leading manufacturer of iron. Iron manufacturing, in common with other great industries, was concentrated in and near the coal fields of England, Scotland, and Wales. Their location along or near the sea greatly facilitated the export of iron manufactures, and later, when the ore supplies ran low in Great Britain, it was easy for the British iron industry to turn to a supply of imported ore from the mountains near the north coasts of Spain and from northern Sweden. Sheffield and Birmingham, in particular, became world-famous producers of iron and steel.

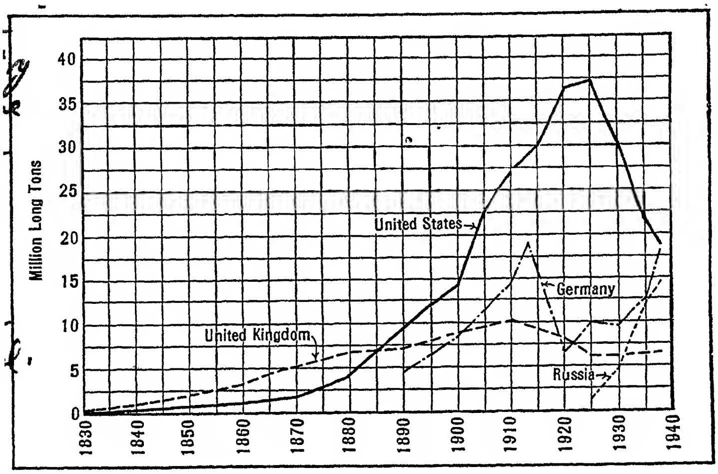
Beginning of the American Industry. The United States is the twentieth-century leader in iron making, as was England during the nineteenth century.

[9] Meredith Givens, *op. cit.*, p. 299.

[10] The furnace consists of a hearth or basin which holds the pig iron, a firebox that contains a coal fire, a sloping roof that deflects the flames down over the hearth, and an air space for generating an ample draught. The molten mass is stirred by a puddler with a long rake. As the carbon burns out, the molten mass changes to a sticky paste, forming balls of puddled wrought iron, which are removed with tongs. Today scrap iron may be added to the charge, and the puddling may be done mechanically. Puddled wrought iron is now used to a limited extent in the manufacture of pipes, fittings, plates, sheets, ornamental iron work, and electrical generating machinery.

[11] U. S. Tariff Commission, *op. cit.*, p. 45.

[12] British output of pig iron increased from 20,000 tons in 1740 to 68,000 tons in 1790, and to 677,000 tons in 1830.



This graph of pig iron production shows that it was only in the second century of its history that the industrial revolution really got under way.

This leadership has come as the result of a number of rapid transformations of the industry in this country. In George Washington's time the little forges or small blast furnaces with a draught forced by a water wheel were scattered from New England to Georgia and from the sea coast to Appalachian valleys in what now seem to be remote and isolated locations. Iron was made wherever the local blacksmiths needed iron, and a good ore bank, waterfall, and the American forest, almost universal in the East, furnished the necessary raw materials. While England was at that time using coke, American coal lay far back in the forests of Pennsylvania and West Virginia, remote from all the paths of easy commerce.

Fortunately for the American iron industry, the first coal field to be developed was the anthracite, which, by its purity and hardness, served well for smelting purposes without being made into coke. Here was a factor that gave one region a heavy advantage over all others, and after 1840 we had a rapid concentration of the iron industry in the Schuylkill Valley and other regions adjacent to the anthracite coal mines of eastern Pennsylvania. The old charcoal forges survived longest in locations remote from the places of superior manufacture and in the isolated mountains of western Virginia, North Carolina, and other parts of the southern Appalachians, where some of them were running for purely local supply as late as the year 1900. A few old, abandoned charcoal forges were temporarily revived during World War I, but they are merely relics of primitive iron making along the roadside today.

The Rise of Pittsburgh. The supremacy of the eastern iron districts was short, because the building of railroads through the soft coal regions of western Pennsylvania caused the introduction there of coke making, for which the coals of the Connellsville Basin were particularly adapted. The manufacture of iron promptly rose in that region, and in 1875 the 900,000 tons of coke-made iron in that region exceeded in quantity

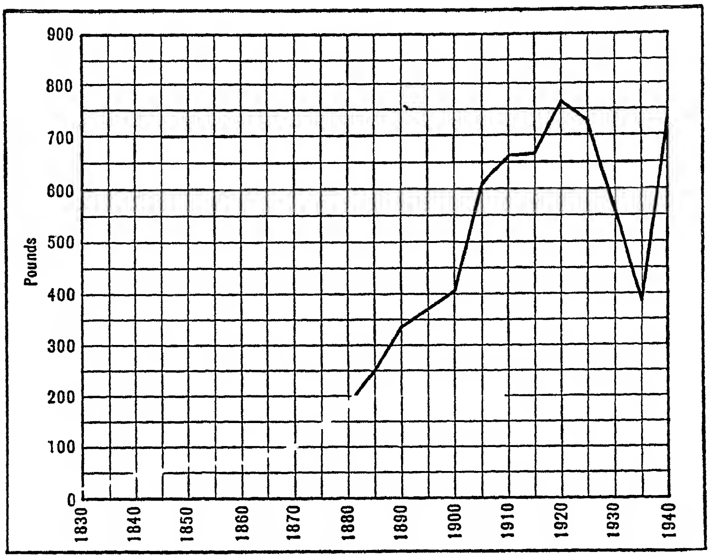
that made with the much more expensive anthracite coal. The enormous expansion of railroads before and after the Civil War and the growth of American manufacturing brought about a rapid increase in the demand for iron. With local iron ores and abundant coke and coal nearby, with good railway connections with the older industrial markets of the East and the growing markets of the Middle West, and with cheap water transportation afforded by a splendid location at a point where the Monongahela and Allegheny join to form the Ohio River,[13] Pittsburgh proved to be a natural spot for the development of a great iron and steel industry. In 1854 iron ore was discovered in the Marquette Range near the western end of Lake Superior, and in the following year the rich ores of this region began to displace Pennsylvania ores in the manufacture of iron at Pittsburgh.[14] Ores from Lake Superior moved cheaply down the Great Lakes to Lake Erie ports and thence by a short rail haul to Pittsburgh. These superb advantages, together with new processes for the large-scale manufacture of steel, soon made Pittsburgh the greatest iron and steel manufacturing center in the United States and, later, the largest in the world.

In retrospect it should be noted that the American iron and steel industry got under way much later than the British industry. Indeed, as late as 1850 about 60% of our demand for iron and steel products was supplied by imports, chiefly from Great Britain. Our output of pig iron for decades was a poor second to the British, and it was not until 1890 that this country came to lead the world.

There is an old English adage that iron ore goes to the fuel, and it is quite apparent that the availability of fuel was a powerful attraction that virtually moved the iron manufacturing industry, from England to the forests of Germany for charcoal and back to England for coke; from the forests of New Jersey, Maryland, Virginia, and the Carolinas to the anthracite of the Schuylkill Valley and thence to the upper Ohio Valley for Connellsville coke. However, it should be recalled that, with the coming of the Industrial Revolution, many other industries likewise gravitated towards the coal fields, man's greatest source of fuel and power. Within or near the coal fields occurred the greatest development of manufacturing in human history, which was accompanied by a remarkable concentration and growth of population. In the midst of such rapidly growing markets occurred the outstanding development of iron and steel manufacturing, an industry that serves other industries. Here was to be found a great demand for the products of iron and steel, together with an ample supply of skilled labor. For decades the great bulk of the world's iron ore has continued to move to such great markets as possess or have easy access to abundant coal. It is here that a pre-

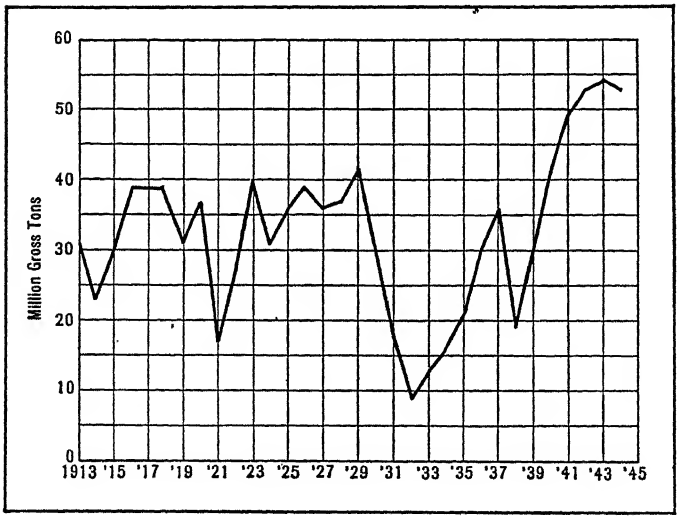
[13] Because of its huge coal trade, the Monongahela ranks second only to the main course of the Mississippi in volume of traffic. Its little tributary, the Youghiogheny, serves the Connellsville coking area. In 1940 the Monongahela handled 29,560,000 tons of freight, or a little more than the entire Ohio River.

[14] The Menominee Range was opened in 1877 and was followed by the Vermillion and Gogebic Ranges in 1884, and the great Mesabi Range in 1892.—Langdon White, "The Iron and Steel Industry of the Pittsburgh District," *Econ. Geog.*, vol. 4, April, 1928, pp. 123-124.



A

The per capita production of pig iron in the United States shows how startlingly this has become the age of minerals, and nearly all of the minerals are a definitely limited resource.

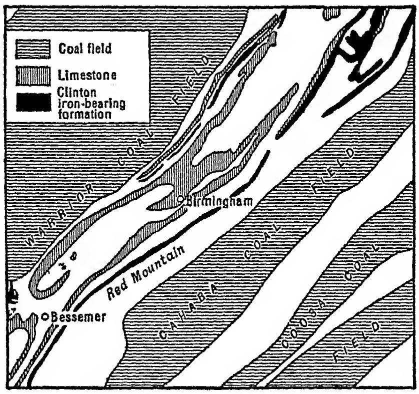


B

Pig iron production in the United States shows how correct is the name "Industrial Barometer" as applied to the production of this basic material.

ponderant share of the world's iron and steel is manufactured today.[15]

The Birmingham District. In northern Alabama, Birmingham, named from the iron and steel city of England, possesses a rare combination of resources for iron and steel production. No other locality has such a natural assemblage of raw materials. On one side of the valley



Map of the Birmingham section of the great Appalachian Valley, famous for the close proximity of the three main raw materials for iron and steel. (Map after Brigham.)

is a deposit of iron ore, on the other side is the limestone necessary for fluxing the furnaces, while shallow coal mines are but a few miles away (see Fig. 148). Offsetting Birmingham's great raw material advantage is its chief handicap, the lack of an industrial market, for the South remains primarily an agricultural region. Furthermore, most Birmingham ores have an iron content of only 30% to 40%, and hence more ore and coal must be used to produce a ton of pig iron. The ore lies deep beneath the surface and is harder than Superior ore, which makes much drilling, blasting, and crushing necessary. Because of its high phosphoric content, pig iron must be subjected to both basic Bessemer and basic open hearth processes to produce quality steel, this duplex process involving a higher cost per ton of finished steel. While the Birmingham district produces well over half of all iron and steel in the South, its sole claim to national leadership is in the manufacture of cast iron pipe. If the South should develop heavy industries on a large scale like those in Pennsylvania and other sections of the North, the Birmingham iron and steel industry will stand to gain. Outside of the Birmingham district, widely scattered blast furnaces and steel plants are generally small and of minor importance. In the aggregate, southern plants produce about 3½% of the nation's steel.[16]

Development of Minor Steel-making Districts. Several minor producing districts exist in the United States. Duluth has a small iron and steel industry based upon the use of local ores and West Virginia and Pennsylvania coal, which is delivered at exceptionally low rates by vessels that are eager to carry coal up

[15] At one time two or more tons of coke were required to smelt a ton of iron ore, and it was obviously economical for iron to move to coal for manufacture, but this ratio no longer holds true, for the modern blast furnace requires as little as ½ ton of coke to smelt a ton of ore. In recent years technological improvements have made it possible to manufacture coke from lower grades of coal, and cheaper railway rates have permitted the transportation of coke over greater distances; hence the good coking coals of Connellsville, the English Midlands, and the German Ruhr have lost much of their monopolistic advantage. Furthermore, new processes have made it possible to manufacture iron and steel exclusively from scrap iron, with the use of petroleum and hydro-electric power as fuel. Such improvements have permitted a more widespread development of the iron and steel industry. Yet, in spite of such decentralizing influences, about 85% of the world's iron and steel is manufactured in six countries today.

[16] Evan B. Alderfer and Herman E. Michl, *op. cit.*, p. 59.

the Great Lakes rather than travel in ballast. At St. Louis iron and steel plants serve a growing market and utilize southern Illinois coal and coke, Lake Superior iron ore, and large amounts of scrap metal. ~~Throughout the coun-~~ try east of the Mississippi are various smaller establishments ~~that make use of~~ scrap metal and local ores, and many of these are remnants of a past era of decentralized iron and steel making that are engaged in a difficult battle with the great steel centers ~~of today.~~[17]

5. *The Technology of Steel Manufacture*

Wrought Iron. In ancient times it was discovered that carbon had the effect of increasing the hardness of iron, making it suitable for the manufacture of weapons and tools. Excellent steel was made in Roman times, and the swords of Damascus and Toledo were famous throughout the medieval world because of their strength, temper, and beauty.[18] Unfortunately, the old art of steel making was lost, and man was forced to develop new processes which through slow trial and error have been gradually perfected in modern times.[19] In his search for a better metal, man was goaded by a definite need. The wrought iron of the Catalan forge and puddling furnace was tough, fibrous, and malleable, but too expensive, whereas blast furnace pig iron was too brittle, although it could be produced cheaply and in large quantities. Between these two was needed a metal that was malleable, that could be tempered to take a fine cutting edge, that was strong and shock resistant, and that could be produced in large quantity at low cost. Technically, the task was primarily to manufacture steel that would not contain too much or too little carbon.[20]

Cementation and Crucible Steel. The cementation process is probably the earliest method of steel-making known to man, and was used in Belgium in the early years of the seventeenth century. It involves the impregnation of wrought iron with carbon at a red or yellow heat.[21] In this process, bars of wrought iron are packed in air-tight boxes with charcoal (carbon) and the whole box kept hot for 7 to 11 days, during which the carbon is slowly absorbed by the iron. The bars become covered with blisters, and the finished product, called "blister" steel, has great hardness but lacks uniformity, as the amount of carbon varies from the surface of a bar to the center. While this process was used for several centuries, it is virtually obsolete today.

The first fine steel was made in 1740 by Robert Huntsman, a watchmaker of Sheffield, England, in search of better material for his watch springs. By melting the bars of blister steel in clay pots, he obtained the desired uniformity. This method developed into the crucible proc-

[17] In New York State one lone blast furnace at Troy remains in operation outside of the Buffalo district today, whereas in 1880 there were many iron furnaces scattered throughout the state.—See Herman F. Otte, *The Expanding Mineral Industry of the Adirondacks,* State of New York, Executive Department, Division of Commerce, Albany, 1943, pp. 17-19.

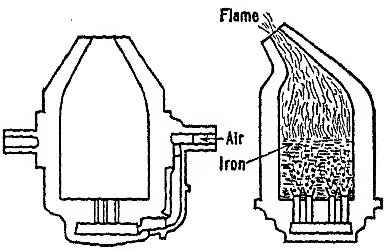
[18] See Tenney Frank, *op. cit.,* p. 232, and James W. Thompson, *An Economic and Social History of the Middle Ages,* The Century Co., New York, 1928, pp. 360, 549.

[19] Evan B. Alderfer and Herman E. Michl, *op. cit.,* p. 40.

[20] The carbon content of pig iron ranges from 3 to 5% whereas that of wrought iron is only 0.05 to 0.25%.

[21] U. S. Tariff Commission, *op. cit.,* pp. 46-47

ess, where wrought iron is melted for about $2\frac{1}{2}$ to 4 hours in a clay or graphite pot, and powdered charcoal or some other form of carbon is put directly in the molten iron. The famous Sheffield tool steel is still made by the crucible process, and is used for fine cutlery, firearms, and instruments of precision. Crucible steel is high-cost steel, as only



A cross-section of the Bessemer converter. The air-blast, driven through the molten pig iron, to burn out the carbon made the first cheap steel in the world nearly 100 years ago and gave us a chance to use it for such things as ship plates and railroad rails at a reasonable price. Notice that the converter is so arranged that it can be inverted and its tons of contents dumped.

about 100 pounds can be made at a time. In the United States this process has been replaced almost entirely by the electric furnace, which can produce high-grade steels with greater economy and efficiency.

The Bessemer Process. The world waited long for low-cost steel, for it was not until 1855 that Sir Henry Bessemer patented a process that made possible the large-scale production of steel.[22] In this process molten pig iron is poured into a pear-shaped vessel, or converter, after which a strong blast of air is forced upward through the molten mass from holes in an air chamber at the bottom of the converter. Violent combustion ensues, the temperature rising to about 3,000° F., the oxygen of the air blast burning out the carbon, silicon, and manganese. Then small but carefully measured amounts of carbon and other alloys are added to the nearly carbonless iron, thereby converting it into steel.[23] By this process 20 or 25 tons of pig iron are converted into steel in about 15 minutes.[24] The molten steel is then poured into a ladle from which it is run into ingot molds. Not long after its invention, the acid Bessemer process was found to be incapable of handling iron containing more than 0.1% of phosphorus. Fortunately, in 1878 Sidney G. Thomas, a young police court clerk and amateur chemist, and his cousin, Percy C. Gilchrist, perfected a method of removing the phosphorus by merely substituting limestone for the sandstone lining used in the Bessemer converter. It was found that the limestone neutralized the phosphorus and removed it, provided that the pig iron had a phosphorus content of 2% or more.[25] Thus, the new basic Bessemer, or Thomas-Gilchrist, process made available for use ores of high phosphoric content, such as those of Lorraine and Birmingham, Alabama.

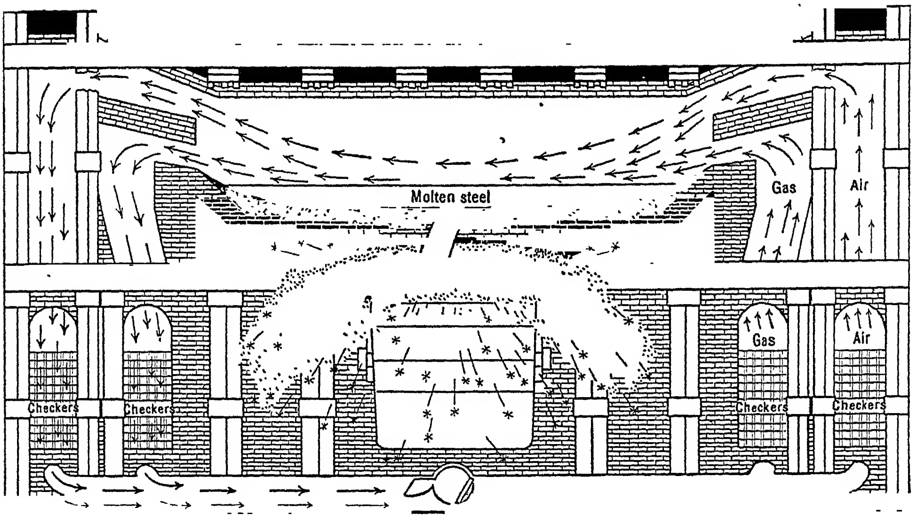
The cheap and speedy Bessemer proc-

[22] William Kelley, a Kentucky ironmaker, was subsequently granted a patent on this process in the United States, because he established the fact that he had developed the process in 1847.

[23] This is now usually accomplished by the addition of ferro-manganese, which reimparts carbon, manganese, and silicon in the desired proportion. Spiegeleisen, or high-carbon iron, is sometimes used.

[24] The capacity of the average Bessemer converter in the United States is about 20 tons; the largest holds 28 tons.

[25] After they become saturated with phosphorus, the limestone linings are ground into a fine powder, known as basic slag or Thomas meal, and sold as phosphatic fertilizer.



Cross-section of open-hearth furnace, showing the bed of molten steel with flames rushing across the top of it and burning out the carbon slowly. Meanwhile, the metal is stirred from time to time in a process called "puddling."

Some of the heated air from the fire is carried around to heat the incoming gas and air which feed the fire.

The pot-shaped thing in the middle is the cross-section of the ladle, supposed to be this side of the hearth. The molten steel is poured into this when the process is finished. The stars represent the sparks of flying metal.

ess soon liberated the railroads from the use of costly wrought iron rails and greatly stimulated shipbuilding, the construction industry, and manufacturing in general. For decades Bessemer steel was used for many purposes, but with the increasing size and weight of locomotives, railway cars, ships, and buildings, it was found that Bessemer steel would sometimes break without warning. Bessemer steel cannot stand the great stress and strain required of heavy steel products today, and hence it is now used chiefly in the manufacture of pipe, wire, and wire products.

The Open-hearth Process. In the year following Bessemer's great invention, Sir William Siemens, an English inventor of German birth, patented the open-hearth process, which eventually came to be the world's chief method of making steel. This process employs a low rectangular furnace containing a shallow basin, or open hearth, that is heated by gas or oil flames. In Siemens' day producer gas obtained from coal was used as fuel, but now the gas of by-product coke ovens, natural gas, petroleum, and occasionally tar or pulverized coal are also used.[26] At each end of the furnace are two openings, one for gas and one for air. Both gas and air enter at one end, the products of combustion escaping from the other, and every 15 or 20 minutes the direction of the flow of gas and air is reversed so that the hearth will be heated uniformly. The gas and air are preheated, and this helps to maintain a temperature of 2,800° to 3,100° F.

Pig iron was the first raw material to

[26] U. S. Tariff Commission, *op. cit.*, p. 48.

be treated in the furnace, but the Martin brothers of Anteuil, France, later discovered that scrap iron, scrap steel, and iron ore could be added to the charge. These materials, together with limestone, make up the charge that is exposed to the heat of the flames for 8 to 15 hours. From time to time slag containing impurities is drawn off. Ferro-alloys and other materials needed to make the desired quality of steel are charged into the furnace itself or are added after the heating process has been completed and the molten steel has been run off into a ladle. The ladle is then carried by an electric crane to a pouring platform, where the metal is run into ingot molds. Since Siemens' day the capacity of open-hearth furnaces has increased from 5 to 400 tons, the average furnace in this country holding about 120 tons. Both acid and basic processes have been developed that can handle pig iron ranging from 0.1% to 2% in phosphoric content. Careful use of alloys and frequent chemical testing of samples while production is under way results in a steel of high quality that is stronger, more uniform, and more reliable than Bessemer steel. Ship plate, rails, boiler plate, structural shapes, and most heavy steel products are now made by the open-hearth process.

A bank of open-hearth furnaces. Little holes in the door let the operator look in to observe the stage of the process. The man at the extreme left is giving a signal to some man out of sight to operate the machinery that tips the huge ladle and pours molten iron into the furnace to recharge it. Too bad Dante couldn't have seen this before writing his *Inferno*. To see these veritable rooms full of molten metal, swinging about by the steel cranes, or running about the plant on little cars, is one of the impressive sights of modern industry.

Ascendancy of Open-hearth Steel. The development of these two steel-making processes was much like the fabled race between the tortoise and the hare. Open-hearth steel got off with a tortoise-like start, its output lagging behind Bessemer steel for half a century, yet today the great bulk of the world's steel is produced by the open-hearth process. In the United States the two processes were of equal importance in 1907, but now approximately 90% of our total output is open-hearth steel.

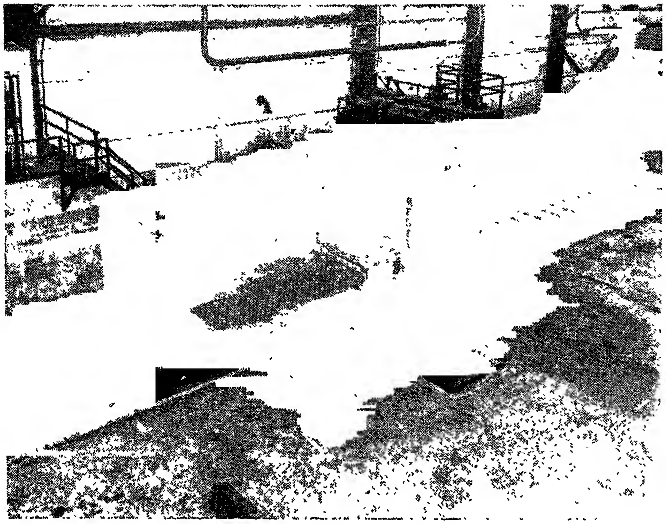
Among the world's major steel producing countries, only in France and Belgium-Luxemburg, which depend heavily upon phosphoric ores of Lorraine, does the Bessemer converter remain supreme.[27] The present-day dominance of open-hearth steel seems rather paradoxical in view of the fact that the speedy Bessemer process needs no fuel and involves a plant investment per ton of capacity only one-fourth as large as that of the open-hearth process.[28] Nevertheless, there were definite factors that contributed to the rise and eventual supremacy of open-hearth steel. As scrap iron, scrap steel, and iron ore came to be increasingly used as part of the charge, as the size of the furnace increased, and as improvements were made, the cost of open-hearth steel declined. Today open-hearth furnaces take scrap metal ranging from 40% to 60% of their output, and some furnaces use scrap exclusively if other materials are too costly or are not available. However, the prime factor leading to the ultimate dominance of open-hearth steel was its quality. Modern industry requires not only a strong, uniform, and reliable steel, but it needs a variety of steels, each differing slightly from the other. With a judicious use of alloys, these can be produced in the open-hearth furnace in large quantity and at reasonable cost. While its cost per ton is higher than Bessemer steel, actually open-hearth steel is low-cost steel when its superior quality is considered. It was the perfection of these two great processes that enabled the world to emerge during the latter part of the nineteenth century from an age of iron into a new era of high-quality and low-cost steel.

The Electric Process. In the closing years of the nineteenth century there appeared in Europe a steel-making process that introduced the use of electricity as fuel.[29] Various types of electric furnaces were soon developed in Italy, Sweden, and France, where hydro-electric power was cheap, and in 1908 the first electric steel was produced in the United States. The electric furnace is generally a spherical steel shell, less than an inch thick, that is lined with basic or acid refractory bricks and which receives its heat from electrodes that extend down from the roof. A few furnaces hold as much as 85 tons, but their average capacity is about 20 tons. The electric furnace is indeed a steel-making factotum, for it may be used to convert cold or molten pig iron into steel, to melt and refine scrap iron or scrap steel, further to refine either Bessemer or open-

[27] Prior to World War II, the ratio of open-hearth to Bessemer steel output was as follows: United Kingdom, 19.5 to 1; United States, 13.6 to 1; Germany, 1.3 to 1; France, 1 to 2.3; Belgium-Luxemburg, 1 to 15. In Russia the Bessemer process is used to a very limited extent.—*Ibid.*, pp. 131, 156, 185, 210, 227, 269.

[28] Evan B. Alderfer and Herman E. Michl, *op. cit.*, p. 45.

[29] The first electric process was set up experimentally by Siemens of England in 1880, but it was not until 16 years later that Stassano of Italy was the first to operate an electric furnace commercially.—*Ibid.*, p. 47.



Impressive also is the rolling mill. A man sitting on a cushion in an armchair, high up where he can overlook the scene, pulls levers. A 7,000 pound ingot of white hot metal moves along, falls down, turns over, rushes into the rolls, to be pressed by several thousand horsepower of energy. By pressure, as it passes between the earth-shaking rolls, the ingot is lengthened and flattened. It stops, rushes back through the rolls and is further flattened and the process continued until the thing may be ⅛ of an inch thick, 10 feet wide and many feet long, or it may become a rod several hundred feet long.

hearth steel, or to provide the final treatment in a triplex process for Bessemer steel that has been refined in an open-hearth furnace. The charge obviously depends upon the use to which the furnace is put; it may include iron ore and limestone, but it always involves the use of alloys. The electric furnace can handle light scrap and shavings that are unsuitable for the open-hearth furnace, and in this country scrap metal is the dominant raw material. About 4 hours are needed to produce a batch of electric steel. The electric process achieves higher temperatures and better control of heat than other processes, and it is claimed that the slag is separated more completely from the metal, that the loss from oxidation is reduced, and that alloys are assimilated more effectively. Hence, the prime function of the electric furnace is in the production of super-quality steel involving the use of especially high-grade alloys.

About 30% of the American output of 13,116,000 tons of alloy steel in 1943 was produced by the electric process, the remainder coming from open-hearth furnaces.[30] Both in this country and abroad electric steel has almost completely displaced steel made by the high-cost crucible process. Between 1910 and 1941 the output of electric steel in the United States increased from 52,000 to 2,562,000 tons, while crucible steel declined from 122,000 to 2,000 tons, a trend.

[30] American Iron & Steel Institute, *Steel Facts*, No. 64, February, 1944, p. 3.

that has also occurred in other countries. Furthermore, it may be noted that during the same period of time our total output of open-hearth steel increased from 16,505,000 to 66,419,000 tons, while Bessemer steel declined from 9,413,000 to 4,980,000 tons. These facts reveal that man's long search for low-cost, high-quality steel has not been in vain and that the long-run trend in modern steelmaking continues upward in the direction of higher quality.

Alloy Steels. Steel in 1900 was simply hard, medium, or soft, depending upon its carbon content, and alloy steel was almost unknown. World War I provided the first great stimulus to the production of alloy steel, since the belligerent governments specified the chemical composition of the various steels that were needed in the manufacture of armor plate, ordnance, airplane engines, army trucks, and other supplies of war. In the nineteen-twenties and 'thirties many industries, especially the rapidly growing automobile industry, made increasing demands for special-purpose steels. Indeed, in 1935 the various makes of average-priced automobiles actually contained 83 different alloy steels.[31] The vast and exacting requirements of World War II caused a great increase in the production of alloy steel, and in 1942 one-eighth of the entire steel output of the United States was alloy steel, as compared with only 1 ton out of 50 in 1910-13.[32]

As never before, the specific needs of consumers are being met by a growing variety of special-purpose, "tailor-made," alloy steels. Thus, tungsten and cobalt, which retain their hardness and cutting qualities under the red heat of great friction, are well adapted to the manufacture of high-speed steel used in metal-

Man turning white hot slab of steel before it goes into the rolling mill. Most modern rolling mills now do this by the touching of levers.

working machinery, such as lathes. Molybdenum and vanadium are strong, tough, and resistant to shock and vibration, and they are used in the production of automobile gears and axles. Nickel and chromium are hard and strong and well suited for the manufacture of armor plate, projectiles, heavy guns, and ball bearings; they also resist corrosion

[31] National Resources Committee, *Technological Trends and National Policy*, Washington, June, 1937, p. 330. Prior to World War II, alloy steel consumers were fastidious buyers, specifying the alloy content in hundredths and even thousandths of a per cent, but, as shortages of strategic alloys developed during the war, consumers merely stated the mechanical properties desired and allowed the steel manufacturers to determine the chemical composition of the steel.

[32] In 1918 the ratio of alloy steel to total output was 1 to 25; in 1929, 1 to 14; and at the beginning of 1943 it was 1 to 6.—American Iron & Steel Institute, *Steel Facts*, No. 58, February, 1943, p. 3.

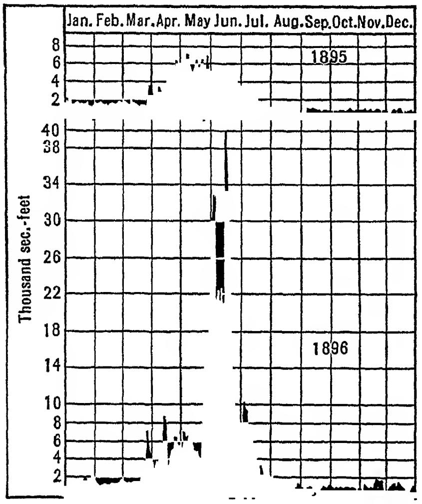
TABLE 14

PRINCIPAL NON-FERROUS METALS USED BY STEEL INDUSTRY

Metal	*Reason for use*	*Typical applications*	*% of world production produced in U. S. in recent years*	*% of world production consumed in U. S. in recent years*	*Chief sources of United States supply*
Aluminum...	Removes gases and impurities	Seldom more than a trace remains in the steel	30	40	United States
Chromium...	Small amounts improve hardening qualities; more than 10% prevents rust	Tools; machinery parts; stainless and heat- and acid-resisting steels	Insignificant	40	Africa, Cuba, Greece, New Caledonia
Cobalt.......	Holds cutting edge at high temperatures. Improves electrical qualities	High-speed cutting tools; permanent magnet steel	None	10	Canada, Belgian Africa, Australia
Copper.......	Retards rust	Roofing and siding sheets	40	35	United States
Lead.........	When mixed with tin, forms a rust-resisting coating for steel. Small amounts alloyed with steel improve machinability	Sheet steel for roofing, auto gasoline tanks, etc.; machinery parts	30	35	United States

Potomac varies according to the amount of rainfall from 1,000 to 250,000 cubic feet per second.

Snow fields and glaciers are second to lakes as natural reservoirs, and they have the particular advantage of releasing the water in time of summer drought and holding it tight in a period of excessive



Discharge of water in cubic feet per second of the Boise River above Boise, Ida., for two successive years. Snowfall does not always duplicate. (Newell, U. S. Geol. Survey.)

winter precipitation. These factors, combining with a heavy rainfall and the high Coast Range, Cascades, and Sierra Mountains, give the Pacific Coast states nearly the largest potential water-power resources of the United States.

If flood waters were stored so that the streams were more fully utilized, it is estimated that it would be practicable to develop in the United States about 80 million horsepower.

Norway and Sweden have unusual water-power resources in their mountains, glacial lakes, glaciers, and snow fields. They have poor coal supply and in their forests a resource demanding power. It is but natural that they, like the Swiss who have similar conditions, should be leaders in water-power development, as shown by the fact that the Swiss are leading water-power engineers and that water power furnishes two-thirds of all the power used in Sweden and three-fourths of it in Norway.

Temperature also affects a region's supply of water power. In areas that have long and cold winters, as in Siberia, the Yukon Valley, and northern Canada, many a river freezes solid for months. At such times the watercourse breaks out through some weak place and flows along the top of the stream, freezing and piling up great masses of ice and flowing about in devious ways to escape its own obstructions. If the land is fairly level, the water-power supply is dissipated with the icy floods that inundate the countryside. If the stream flows through a narrow gorge, great ice jams are formed that hold back the water. When the thermometer remains at 30, 40, or 50 degrees below zero for weeks at a time, stream-flow is reduced, particularly in the upper course and small tributaries. Extremely cold temperatures for prolonged periods of time resemble drought in power to injure a dependable, year-round water-power supply.

Dry summer lands like the Mediterranean countries and California are greatly handicapped for water power unless they happen to possess mountains where snow fields and glaciers melt in summer and furnish a flow when the rains do not come. Thus, the snow-fed waterfalls of the Alps have been put to use by the Swiss and Italians who have no coal, and the waterfalls of the Sierra Nevada Mountains in California are al-

and enter into the production of stainless steel, which is used for laundry and milk-bottling machinery, chemical vats, airplane wings, and other products that require a rust-proof metal. Manganese, being tough and resistant to abrasion, is well suited to the manufacture of safes, mining machinery, and rails that are used on curves.[33] At one time it was thought that copper was deleterious to steel, but now it is known that a few tenths of a per cent of copper greatly increase the resistance of steel to atmospheric corrosion.[34] With the use of alloys, it is now possible to manufacture steel to serve almost any purpose and to make steel products that will last much longer than formerly. As metallurgical research continues, the results may well be even more miraculous than the achievements of the past.

In the final stage of production the steel ingots from the Bessemer converters and open-hearth and electric furnaces are sent through various roughing and finishing mills that give the desired shape for the final finished products.

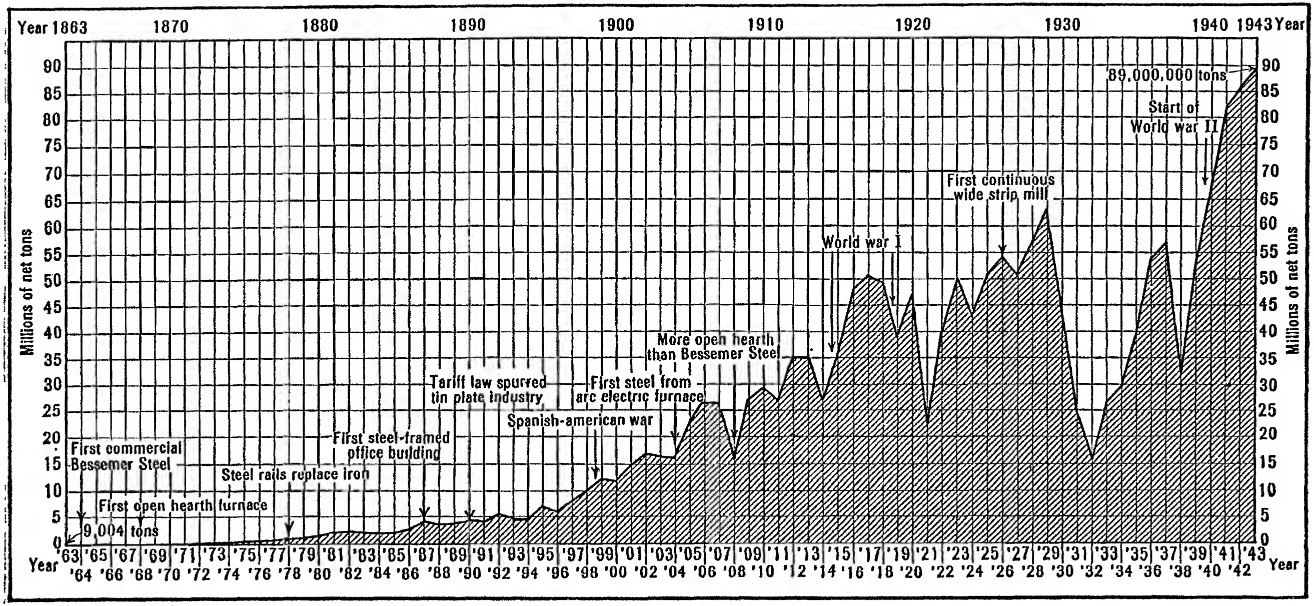
6. *Changes in the Location of the American Iron and Steel Industry*

Prerequisites of a Great Iron and Steel Industry. There have been many changes in the processes of steel making—the increased use of scrap, new grades of coking coal, the use of petroleum and electricity for heat, wider range of ores, better transport. These changes and new markets have made important shifts in the location of the steel industry and have caused the rise of minor production centers. However, it should be emphasized that the manufacture of iron and steel is definitely *not* a frontier industry, for it shuns the sparsely populated regions almost as nature abhors a vacuum. In contrast with the cotton textile and other footloose industries that have spread throughout the world, iron and steel manufacturing is concentrated in remarkably few areas that possess certain advantages. Specifically, it may be said that four prerequisites are indispensable to the large-scale development of iron and steel manufacturing, namely, (1) easy access to an abundant supply of iron ore of desirable quality, (2) easy access to a large supply of coal suitable for smelting and refining, (3) nearness to a densely populated, industrialized market with a large and growing demand for iron and steel products and with an increasing supply of scrap metal, and (4) access to an adequate supply of capital and skilled labor, including men with the executive and technical ability needed to organize and operate a large and complex industry.[35] In conjunction, these four advantages

[33] Other examples include the use of beryllium in the manufacture of airplane engines, cadmium in bearings, columbium to improve the welding properties of stainless steel, indium in the wearing parts of engines and machines, silicon in springs and electrical apparatus, tantalum in cutting tools, and zirconium in armor plate.—See Charles K. Leith, James W. Furness, and Cleona Lewis, *World Minerals and World Peace,* The Brookings Institution, Washington, 1943, pp. 23-31, and U. S. Army, *Strategic and Critical Raw Materials,* Army Orientation Course, Washington, 1942, pp. 38-49.

[34] About 15% to 20% of all iron that is mined is eventually lost through corrosion. For an able account of man's battle with corrosion, see National Resources Committee, *op. cit.,* pp. 346-349.

[35] For a detailed analysis of the location factors underlying the iron and steel industry, see Erich W. Zimmermann, *World Resources and Industries,* Harper & Brothers, Publishers, New York, 1933, pp. 585, 612-665, and Evan B. Alderfer and Herman E. Michl, *op. cit.,* pp. 57-66.



Here is one kind of a history of the United States. This covers the period when railroads became more than a local institution, when cities became more than six stories high and nearly everyone began to travel much more than ever before in human history.

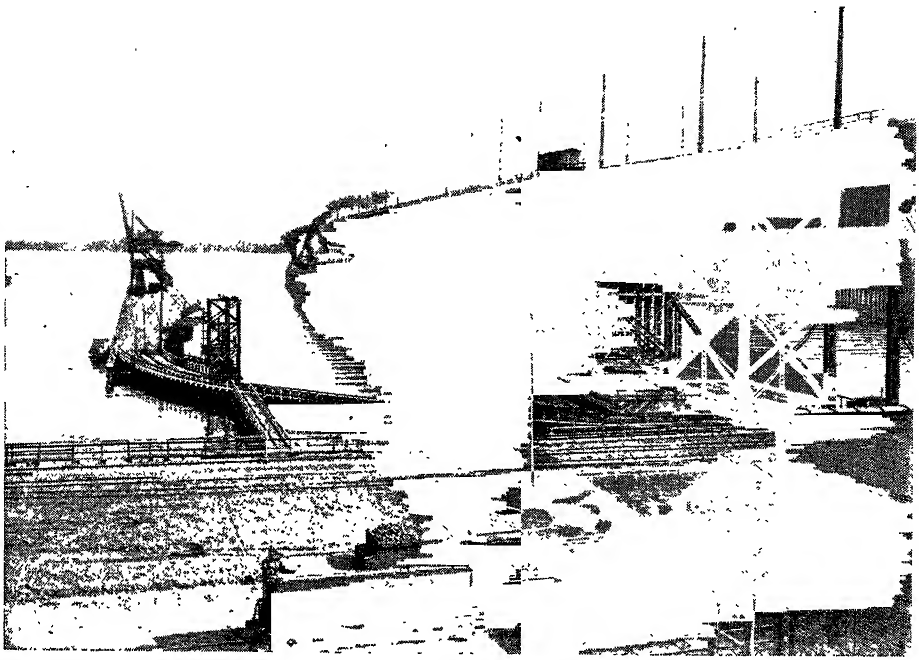
make production costs low. They explain the location and success of the great iron and steel industries that have arisen in the past. To the extent that these advantages are present or lacking determines the ultimate success, mediocrity, or failure of any newly established iron and steel center. Tariffs should ever be kept in mind when considering any steel-producing area, especially the minor ones.

Pittsburgh, as we have seen, had peerless advantages that enabled it to become America's foremost iron and steel center.[36] As the city is cut by valleys and gulches, level land available for factory sites became crowded years ago, and the iron and steel industry overflowed into adjacent territory. Around Pittsburgh developed a cluster of steel towns including McKeesport, Braddock, Carnegie, Homestead, and Donora, and at outposts such as New Castle and Johnstown. The industry also spread northward up the Shenango Valley to Sharon, Pa., up the Beaver-Mahoning Valley to Youngstown and into other eastern Ohio towns, and down the Ohio River to Weirton, Steubenville, Wheeling, Huntington, Ashland, Ironton, and Portsmouth. Pittsburgh and its industrial satellites now manufacture about 45% of the nation's steel, or about as much as the normal output of Germany and France combined.

The Great Lakes Steel-making District. The supremacy of Pittsburgh did not remain long unchallenged, for the twentieth century witnessed an important migration of the iron and steel industry to the southern shores of Lake Erie and Lake Michigan. As early as 1900, the Lackawanna Steel Company recognized the value of a lake shore site, where the ore steamer could unload its cargo alongside of the blast furnace, and moved its plant from Scranton, Pa., to the vicinity of Buffalo. Along the Lake Erie shore today are found many iron and steel plants, varying in size and in the nature of their products, in Buffalo, Erie, Ashtabula, Conneaut, Cleveland, Lorain, Sandusky, and Toledo, and also in Detroit.[37] The iron ore trains running southward from many of these Lake Erie ports often return with coal and coke, which makes the freight rate lower in both directions. In 1907 the United States Steel Corporation, perceiving the importance of Chicago and the growing markets of the Middle West, laid out the town of Gary, Ind., and set up a huge steel plant. Since then many other plants have been set up at Gary and nearby towns, where Superior ore meets southern Illinois coal and coke

[36] *Cf. supra,* p. 146. The supremacy of Pittsburgh was further enhanced by the formation in 1901 of the gigantic United States Steel Corporation, which from 1903 to 1924 pursued a price policy known as "Pittsburgh plus." Under this policy consumers outside of the Upper Ohio Valley were charged the price prevailing in Pittsburgh plus freight charges from Pittsburgh. Thus, if a consumer in Montgomery, Ala., purchased a product from a Birmingham plant that produced it at a lower cost than in the Upper Ohio Valley, he had to pay the Pittsburgh price plus a charge for freight as though the products had been shipped from Pittsburgh.

[37] The iron and steel industry has been Cleveland's leading industry since 1828, when a little iron furnace with a weekly output of 20 tons was established, but the industry does not dominate the municipal economy as does that of Pittsburgh. In recent years a few steel companies have set up plants in Detroit to serve the automobile industry from which they can always obtain a large supply of scrap metal. These plants can deliver their products quickly by motor truck to the automobile factories, which maintain low inventories and want steel on short notice. The Ford Motor Company has its own huge plant at River Rouge. About one-third of Detroit's demand for steel is now supplied by local plants.



Ore dock at the upper lakes long enough to load several 600-foot ships at the same time. The ore train from the mine runs out on the dock, drops its load through the bottom of the car into bins on the pier. Spouts are lowered and by gravity the ore runs with a roar from the bin on the pier to the hold of the ship.

The Missabe and Iron Range Ore Dock, No. 6, Duluth, at the left, received cargoes of limestone and some soft coal.

for manufacture.[38] The world's two largest steel plants are now located at Gary and South Chicago. Gary today is Pittsburgh's leading rival. Here on the level plains that bound Lake Michigan and Lake Erie is ample room for expansion, and blast furnaces and steel mills never lack a water supply for industrial purposes.[39] To these waterfront sites come the specially built ships that carry huge cargoes of iron ore from the head of Lake Superior at remarkably low cost.[40] Likewise, the heavy limestone needed as a flux is brought cheaply in ships from the quarries at Alpena, Mich., and from Kelly's Island, Ohio. Finished steel products are distributed quickly and at reasonable cost

[38] At one time all coke had to be brought from Connellsville, Pa., which was not a serious handicap, as coking coal is but a small part of the total coal requirements of an iron and steel industry. This situation was alleviated later by the discovery of coking coal in southern Illinois.

[39] The iron and steel industry of this country consumes about 4 billion gallons of water a day. About 40% is used to generate steam; 30% is needed in steel plants to operate hydraulic machinery, to cool furnace doors and rolls, and to wash away scales that form on steel during the rolling process; 20% is used for cooling blast furnaces, 7% for quenching white-hot coke as it comes from the ovens, and 3% for miscellaneous purposes, including sewage disposal.

[40] To move a ton of iron ore from the head of Lake Superior 800 or 900 miles to Lake Erie ports costs only 83 cents per ton, as compared with a railway rate of $1.15 to carry it little more than 100 miles on to Pittsburgh.—Carroll R. Daugherty, Melvin G. de Chazeau, and Samuel S. Stratton, *The Economics of the Iron and Steel Industry*, vol. 1, McGraw-Hill Book Co., New York, 1937, p. 380.

over a dense network of railroads that serve a large and productive hinterland. With such excellent transportation facilities and with a prime location in the midst of big cities and many factories, these lake-shore steel-making plants are well able to serve a splendid market.[41] In recent decades no other area has equaled the progress achieved by the Great Lakes' steel-making district, which now produces over a third of the nation's steel.

The iron-ore ranges around the head of Lake Superior mean much to America's two greatest steel-making districts. These ranges normally produce 80% to 85% of all the iron ore mined in this country, and in 1943 they yielded the staggering total of 84½ million tons. Three-fourths of the output of the Lake Superior district, or over three-fifths of the nation's total supply, comes from the great Mesabi Range, where open-pit mining methods are used almost exclusively.[42] As a result of past digging, the Mesabi ore pits are now large enough to contain several large football stadiums and deep enough to hold a building 30 stories high. Far down in these man-made canyons giant electric shovels grab as much as 16 tons of ore at a single bite, dumping the ore into heavy-duty motor trucks or on conveyor belts which carry the ore to railway cars that transport the ore from the floor of the pits to the ore docks at the twin ports of Duluth and Superior.[43] When the cars reach the top of these high docks, the hopper bottoms are opened, and the ore slides by gravity into storage bins and thence by chutes into the cargo hold of a lake vessel at the rate of 100 tons per minute. When the hatch covers are pulled back for loading or unloading, the ship resembles an open barge, but it may hold 12,000 tons of iron ore or even more. When the vessel arrives at destination, huge clam-shell buckets unload the ore within a few hours. From ore pit to blast furnace, "up by electricity or steam and down by gravity" is the common rule of practice.

Manufacture Along the North Atlantic Coast. The iron and steel centers of the East are unable to make any great use of the rich Superior ores because of the length of the rail haul and high transportation costs. Hence, these centers must rely heavily upon the use of scrap metal obtained from the great industrial markets of the East and upon iron ores imported from such varied sources as Chile, Cuba, Sweden, Brazil, Australia, Newfoundland, Spain, and Algeria. Small amounts of iron ore from local deposits, the Adirondacks, and the Lake Superior region are often mixed with the foreign ores. The location of plants at or near the seaboard facilitates not only the importation of iron ore and various alloys but also the shipment of heavy iron and steel products to our Gulf and Pacific coasts and to foreign countries. The largest eastern steel plant at Sparrows Point, near Baltimore, rivals those of Gary and South Chicago in size, and it is owned by

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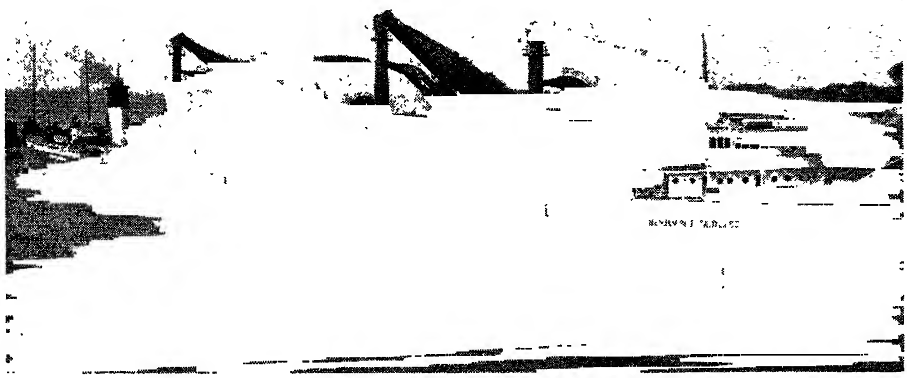
41 See J. Russell Smith and M. Ogden Phillips, *North America*, Harcourt, Brace & Co., New York, 1942, pp. 472-492.

42 Underground workings predominate in the other ranges; about 95% of all open-pit ore comes from the Mesabi Range.

43 Railroads connect the Vermilion and eastern Mesabi Range with the port of Two Harbors, the Mesabi and Cuyuna Ranges with Duluth and Superior, the Gogebic Range with Ashland, the Marquette Range with Marquette, and the Menominee and eastern Marquette Ranges with the Lake Michigan port of Escanaba.

the great Bethlehem Steel Corporation, which imports ore in its own ships from its own iron mines near Santiago, Cuba, and at El Tofo in northern Chile. This plant and those at Bethlehem, Allentown, Lebanon, and Steelton in southeastern Pennsylvania manufacture most of the iron and steel in the East, a sec-



Benjamin F. Fairless, most modern type of Great Lakes ore-carrying boat—637 feet long, capacity more than 18,000 tons. These boats make the round trip from Duluth to Conneaut, Ohio, the port for the United States Steel Company's Pittsburgh plants, in five and a half to six days, and keep it up during the eight months that the lakes are open for navigation. Overhauling is done in winter, in a drydock if necessary.

The ship in this picture is being unloaded by a battery of Hulett Electric Ore Unloaders, each costing $60 more per hour to operate and taking 17 to 20 tons at a bite, or 600 tons or more per hour—at established rates of from 9¢ to 22¢ per ton for handling, depending on the amount that is done on the operation. The big ships are unloaded in from two and a half to four hours and are on their way back for more.

Andrew Carnegie was the last man who ever did or probably ever will own a modern steel-making enterprise. The United States Steel Corporation has 76 ore-carrying boats on the lakes, 52 of them have more than 10,000 tons capacity. They carried 36 million tons in 1942, or 150 thousand per day.

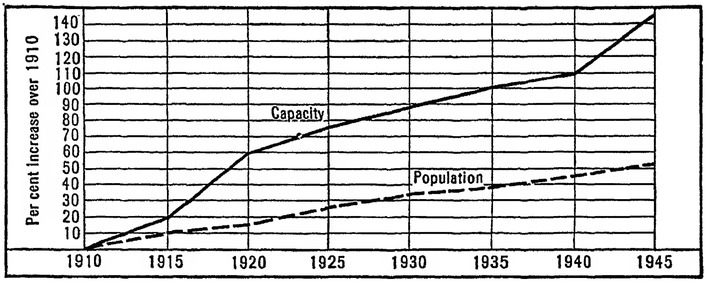
The loads that are taken up by this unloading machine may be deposited immediately into cars bound for Pittsburgh in 125 car trains, averaging 84 tons to the carload and drawn by three locomotives. They reach Pittsburgh, 141 miles away in 10 hours, after stopping to switch cars to various plants.

A speed of technological improvement in America is indicated by the fact that in 10 years this railroad has, by using better metals and better arrangements, and better machines, increased its train speed 32%, its car load 39%, and its train load by 68%.

Some of the ore will be left at the dock of the lake shore for movement during the winter. As the season advances, miniature mountain ranges of ore rise beside the docks. A bridge nearly 600 feet long, supported at the ends on wheels, runs up and down the length of the pier and from it ore drops down to build the mountains and from it clam-shell buckets drop down to pick up the mountains and load them into cars for Pittsburgh plants through the winter.

This takes planning. Each steel plant needs 10 grades of ore to meet its needs. This knowledge must be in the minds of the men who load the ships at the upper lakes and the minds of the men who unload them and pile the stock piles and also in the minds of the men who load the freight cars. Indeed the winter's work must be planned and stock piles at the lake shore built accordingly.

This story of the ore boat and the ore is typical of an increasing part of American industry. It is one of the things that Hitler and Company and the Japanese War Lords didn't understand and really didn't know about when they thought they had the world by the tail and set out to take possession.



This graph of steel capacity and population is based on the figures of 1910 as 100%. In the age of power and machinery, it is an excellent index of potential wealth.

tion that produces approximately 15% of the nation's output.

The iron and steel industry of the West is largely subsistence manufacturing serving local and limited markets. At Pueblo, Colo., nearby supplies of good heating and coking coal and iron ore from eastern Wyoming are used in the manufacture of steel rails, mining machinery, farm implements, and various foundry and machine shop products that are sold throughout the Rocky Mountains and the western plains.

A recent development is the $200,000,000 Geneva steel plant, which was built near Provo, Utah, by the Defense Plant Corpn. during the war. In 1946 its future is full of interesting question marks. A thousand miles of distance and high railway rates protect these industries from the competition of eastern steel centers. Along the coal-poor Pacific coast are half a dozen steel-making plants in the Los Angeles, San Francisco, and Puget Sound areas which use small amounts of local ore and depend heavily upon scrap metal, nearly three-fourths of which is imported from eastern United States via the Panama Canal.[44] The shipyards, factories, foundries, and 10 million inhabitants of the Pacific states continue to depend chiefly upon the great steel-making centers of our Atlantic seaboard and western Europe for manufactured iron and steel.

Between 1870 and 1943 the production of steel in the United States has increased from 40,000 to 88,870,000 tons. The significant geographical fact is that about four-fifths of the output now occurs in the Pittsburgh and Great Lakes areas. The American iron and steel industry has definitely come of age, and further important shifts in its location are not likely to occur.

7. *Changes in the British Iron and Steel Industry*

Growth of Foreign Competition. A few countries have long manufactured the great bulk of the world's iron and steel, and for many decades the lion's share was British. Of the world's output of 4,470,000 tons of pig iron in 1850, about 50% came from British blast furnaces, and British plants turned out over 70% of the world's production of

[44] In 1940 the Pacific states produced only 11,800 tons of iron ore; they consumed 189,000 tons of pig iron and 1,202,000 tons of iron and steel scrap.—U. S. Dept. of Interior, *Minerals Yearbook, Review of 1940*, Washington, 1941, pp. 510, 546.

71,000 tons of cementation and crucible steel. Following the discoveries of Bessemer, Siemens, Martin, Gilchrist, Thomas, and others, it was Great Britain that led the world out of the age of wrought iron and high-cost steel into the modern era of large-scale steel production. The British output of steel ingots and castings increased rapidly from 220,000 tons in 1870 to 4,900,000 tons in 1900, and to 13,500,000 tons in 1939. During the war year of 1943, British steel manufacturers achieved a record output of about 15,000,000 tons.[45] Yet in spite of the great increase in production, British dominance was soon shattered by the development of iron and steel manufacturing in other countries (see Table 15). Indeed, Great Britain has been surpassed by the United States since 1890,[46] by Germany since 1894, by Russia since 1934, and in occasional years by France. As a result of increasing competition, the British

TABLE 15

THE GROWTH OF STEEL PRODUCTION, 1870–1939

(Millions of long tons)

Year	*United States*	*United Kingdom*	*Germany*	*Russia*	*France*	*Belgium-Luxemburg*	*Japan*	*World total*
1870	0.04	0.22	0.13	0.01	0.08	....	....	0.51
1875	0.38	0.71	0.32	0.01	0.21	0.05	....	1.79
1880	1.25	1.29	0.69	0.29	0.38	0.13	....	4.18
1885	1.71	1.89	1.20	0.19	0.55	0.15	....	6.19
1890	4.28	3.58	2.10	0.38	0.67	0.32	....	12.28
1895	6.11	3.26	3.83	0.86	0.86	0.58	....	16.65
1900	10.19	4.90	6.36	2.16	1.54	0.81	....	27.83
1905	20.02	5.81	9.51	2.21	2.22	1.48	....	44.22
1910	26.09	6.37	12.89	3.48	3.36	2.50	0.24 †	59.33
1915	32.15	8.55	12.09	4.82	1.07	1.07	0.50	65.57
1920	42.13	9.07	8.40 *	0.16	3.73 *	1.80	0.83	71.30
1925	45.39	7.39	12.00 *	1.84	8.88 *	4.56	1.32	88.93
1930	40.70	7.33	11.36 *	5.46	11.24 *	5.54	2.29	93.10
1935	34.09	9.86	16.19	12.32	6.18	4.79	4.63	97.86
1939	47.15	13.50	22.89 ‡	18.65	8.47	4.86	6.34 ‡	136.00

* German data for 1920–25–30 exclude the Saar; French data for these years include the Saar.
† Data as of 1913.
‡ Data as of 1938.

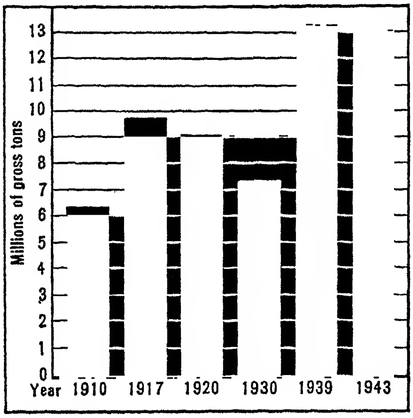
Source: Compiled from Ervin Hexner, *The International Steel Cartel*, The University of North Carolina Press, Chapel Hill, N. C., 1943, Appendix VI, pp. 324–25. World total production in 1939 is a provisional estimate; League of Nations, *Statistical Year-Book of the League of Nations, 1940-41*, Geneva, 1941, p. 141.

[45] Estimate by Walter S. Tower, President, American Iron and Steel Institute, in his letter of January 28, 1944. (A high estimate. See Fig. 166.)

[46] American production first exceeded the British output in 1886 and 1887.—Ervin Hexner, *op cit.*, p. 324.

share of the world's total output of steel has declined from 43% in 1870 to 18% in 1900, and to about 10% in 1939.[47] At the outbreak of World War II, the United States, Germany, Russia, and Great Britain manufactured three-fourths of the ~~world's~~ steel.

Shifts in Location. In recent decades the principal change in the location of



Comparison of the British steel industry with the American steel industry (Fig. 159) shows that Britain has become almost an industrial pigmy, incapable of great expansion under war pressure. The relative degrees of mechanization and scale will help to explain this.

the long established British iron and steel industry has been the tendency to set up new blast furnaces and steel mills along the ~~seaboard~~, which has an advantage over inland localities in the exportation of heavy steel products and in the importation of iron ore, pig iron, scrap iron, and alloy materials. For years British manufacturers have found it necessary to mix richer foreign ores with local ores, which average only 30% in metallic iron. About 85% of the domestic ore is mined in the Cleveland Hills of northeastern England and in the Midlands field along the southeastern flank of the Pennine Mountains, whereas the foreign ore comes chiefly from Spain, Sweden, and North Africa.[48] Nearly half of all iron ore smelted in Great Britain is now of foreign origin. In spite of the abundance of iron and steel scrap in this industrially mature country, British iron and steel manufacturers import as much as a million tons of scrap a year. In view of these facts, it is not surprising that nearly two-thirds of the pig iron and steel are now manufactured in tidewater localities.

Principal British Steel-making Districts. Along the northeastern coast of England, within 25 miles of the Cleveland Hills and the great Northumberland-Durham coal field, is Britain's leading steel-making district, with its center at Middlesbrough near the mouth of the River Tees. Here are to be found the most modern blast furnaces and steel plants in Great Britain, producing more than one-fourth of the nation's pig iron and steel. At Glasgow

[47] Following World War I, the British iron and steel industry was burdened by many outmoded plants and old equipment, by heavy fixed charges due to excessive capitalization, and by rising costs of coal, iron ore, and labor. It was hampered by conservative management, and technical progress lagged behind that achieved in other major steel-making countries. Conditions became so acute that in 1932-35 the Government imposed import duties of 33⅓% ad valorem on a wide range of iron and steel products pending reorganization of the industry. A number of small firms were absorbed by larger units, many plants were modernized, capital was written down, and in 1934 the British Iron and Steel Federation was formed to represent British producers in making agreements with continental members of the International Steel Cartel in regard to output, exports, imports, and prices.—See U. S. Tariff Commission, *op. cit.*, pp. 199-203.

[48] Other sources of ore are France, Sierra Leone, and Newfoundland. Two-thirds of the pig iron imports come from western Europe; the remainder, chiefly from India. About three-fourths of all iron and steel scrap imports are obtained from the United States.

and in the nearby Scottish Lowlands and around Barrow on the northwestern coast of England are other important steel-making districts. With the exception of the Swansea district in South Wales, which specializes in the manufacture of tin plate, all of these coastal districts produce a great variety of heavy steel products, such as rails, ship plate, structural steel, and crude steel for further fabrication. On the other hand, production in the inland districts is on a smaller scale, and such centers as Sheffield and Birmingham manufacture chiefly high-quality steels for making tools, cutlery, and other products of high value.

8. *Iron and Steel Production in Continental Europe*

On the crowded continent of Europe the national frontier looms large in the life of every industry and every inhabitant, a fact that is seldom appreciated by British and Americans who have seen their industry and commerce develop and thrive under conditions of long established national unity and comparative security and peace. In continental Europe industrial development has long been confronted with the uncertainty arising from the vicissitudes of war, shifting international boundaries, and the vagaries of tariff making. Bullet wars and tariff wars make costly readjustments necessary. In any appraisal of the European iron and steel industry, the unstable political factor in the equation of industrial development is too important to be ignored.

The Great German Steel Industry. Two notable gains from the Franco-Prussian War set the stage for rapid and large-scale industrial development in Germany. One was national unity achieved by the creation of the German Empire at the conclusion of the war in 1871, which brought the formerly independent and semi-independent German states under the control of a strong national government. The other gain was Alsace-Lorraine, which victorious Germany acquired from France. In Lorraine are the largest iron ore reserves in all of Europe, located only 150 miles south of the excellent coking coals of the Ruhr Valley, truly a grand prize for steel-making. Luckily for Germany two Englishmen, Gilchrist and Thomas, perfected a process in 1878 making it possible to remove the undesirable phosphorus from Lorraine iron ores, and between 1880 and 1913 the German steel output increased from 690,000 to 17,320,000 tons. The Rhineland-Westphalian area, including the Ruhr, became the most highly industrialized area and greatest steel-making district of continental Europe,[49] and secondary steel-making centers developed in the Saar Basin and Upper Silesia, both being well endowed with coal. A considerable manufacture of iron and steel also developed in Lorraine, since trains moving northward with iron ore could return filled with Ruhr coal and coke. Such large steel-making centers as Essen, Bochum, Gelsenkirchen, and Solingen, and indeed all of the great manufacturing cities of Germany, are served by a veritable labyrinth of railroads, canals, and navigable rivers that

[49] In 1936 about 70% of the German output of steel ingots and castings occurred in the Rhineland-Westphalian area, and about 12% in the Saar Basin.—*Ibid.*, p. 147.

facilitate the movement of heavy freight in almost every direction. The Rhine River is one of the world's busiest waterways and provides the Rhineland-Westphalian industrial area with cheap and easy access to the sea.

World War I dealt a heavy blow to the German iron and steel industry, as the return of Alsace-Lorraine to France, the cession of part of Upper Silesia to Poland and Czechoslovakia, and the loss of the Saar Basin for 15 years deprived Germany of about 70% of her iron ore and 12% of her coal reserves. In terms of pre-war output, Germany lost areas that produced more than three-fourths of her iron ore and nearly one-third of her coal and that contained about one-third of her steel works and rolling mills.[50] To meet these losses and to improve the competitive position of the iron and steel industry, much old equipment was abandoned and many new blast furnaces and steel plants were built, coal and iron mining was more extensively mechanized, the lean iron ores scattered throughout the country were exploited more intensively,[51] greater use was made of scrap iron and steel, long-term contracts were made with Swedish interests for the future delivery of iron ore, competition among German firms was reduced to a minimum through corporate mergers and large combinations and cartels,[52] and cooperation was achieved with other European producers through the gigantic International Steel Cartel.[53] The success of this readjustment program is shown by the fact that by 1925 Germany had regained her position as the world's second greatest manufacturer of iron and steel and that in 1938 her steel output was three times larger than it was in 1913.

The Germans have always found it necessary to import large amounts of the richer and purer ores of Sweden and Spain to mix with local ores and those of Lorraine.[54] Because of the shift of international boundaries following World War I, about 71% of the iron ore consumed by the German iron and steel industry in 1937 was of foreign origin, as compared with 30% in 1913. The Germans worried that their supplies of foreign ores might be cut off in time of war, and it will be recalled that Hitler's legions seized Alsace-Lorraine early in World War II. Nevertheless, the remarkable recovery and expansion of the German iron and steel industry between World War I and World War II demonstrates that in times of peace the German industry has cheap and easy access to the iron ores of France, Sweden, and Spain. Dependence upon foreign raw materials is *no* real handicap, if tariff barriers and other man-made obstacles do not impede the flow

[50] *Cf. ibid.*, p. 145, and William O. Blanchard and Stephen S. Visher, *Economic Geography of Europe*, McGraw-Hill Book Co., New York, 1931, p. 251.

[51] The principal iron mining areas are the Siegerland and Lahn-Dill districts in the west not far from the Ruhr, the Peine-Salzgitter district in the north central part of the country, and the Bavarian district in the south.

[52] In 1926 six large firms were merged into one large company, the Vereingte Stahlwerke, A. G. (United Steel Works), which manufactures one-half of the nation's iron and steel. The Krupp and Gutehoffnunghütte concerns are the second and third largest producers. The Krupp works at Essen has long been famous for the production of armament.

[53] For a thorough analysis of the operation of this cartel, see Ervin Hexner, *op. cit.*

[54] Local ores average less than 25% in iron content; Lorraine ores range from 25% to 45%; Spanish ores, from 48% to 58%; and Swedish ores, from 58% to 72%.

of trade and if nations such as Germany can be taught that it is worth while to maintain peace. What will be the nature and location of the German steel industry in the decade 1946-56? In large part the answer lies in the lap of the gods, or more specifically with the United Nations, so called.

France, Belgium, and Luxemburg. The resource situation underlying the French iron and steel industry further reveals the desirability of peace and economic cooperation among the nations of western Europe. In contrast with Germany and Great Britain, which have long been rich in coal and are now vitally dependent upon foreign iron ore, France is now rich in iron but has long been the world's greatest importer of coal. The return of Alsace-Lorraine in 1918 doubled French iron ore reserves, and France soon became the world's second largest producer and the leading exporter of iron ore. About one-half of the French output of iron ore is usually exported, 95% of the exports moving by rail to the nearby steel-making districts of Belgium and Germany. On the other hand, rising costs of domestic coal and the increasing demands of industry make it necessary for France to import about one-third of its coal supply, 90% of the imports coming from Great Britain, Germany, Belgium, and Holland. Furthermore, little French coal is good enough to be used in the manufacture of coke, and most of the coke consumed by the French iron and steel industry is either imported or is produced locally from imported coking coals. About two-thirds of the coke and most of the coking-coal imports come from Germany, the remainder being supplied by Holland and Belgium. These facts clearly indicate that the basic steel-making resources of France and those of her neighbors are highly interdependent.

By far the most important steel-making district of France is the Lorraine Basin, which manufactures about three-fourths of the nation's pig iron and steel. As this area is not well endowed with coal, it draws heavily upon the excellent coal and coke of the German Ruhr. The Lorraine iron ore deposits yield about 95% of the total output of France, and most of them are easily worked by open-pit methods. Because of their high lime content, these oolitic limonite ores do not require the addition of limestone as a flux, but their high phosphoric content makes the basic Bessemer and basic open-hearth processes necessary in steel making. Blast furnaces and steel plants are situated in the vicinity of the iron mines near Metz, Briey, Nancy, and Longwy. Some of the crude steel is shipped to plants in other parts of the country, such as the great armament plant at Le Creusot. Another steel-making district is found in the Sambre-Meuse coal mining area of northern France, where proximity to seaboard facilitates the importation of high-grade coal and coke from Great Britain and Holland. Iron ore is secured from Normandy, Luxemburg, and Lorraine. As this steel-making district lies in the midst of a great industrial area, large amounts of scrap metal are used in the manufacture of both pig iron and steel. Here in the North and in Lorraine is manufactured over 90% of the nation's

iron and steel, which has doubled in output since 1913.[55]

In contrast with other international boundaries in western Europe, the boundary between Belgium and Luxemburg is a frictionless line with no tariff barriers since the two countries were joined together in a customs union in 1922. This sensible arrangement, permitting complete freedom of trade, promotes the effective use of the natural resources of both countries and has stimulated the manufacture of iron and steel. Prior to World War II, Belgium-Luxemburg ranked sixth or seventh among the nations of the world in the production of steel and usually first or second in steel exports. Although Belgium has coal and Luxemburg has iron, about 70% of the iron ore and 40% of the coke consumed each year must be imported.[56] As the combined area of these two countries is not much larger than that of Maryland, short hauls facilitate the assembly of raw materials and the distribution of finished products.

The Industrial Triangle of Western Europe. These iron and steel districts of western Europe supply the needs of many industries that are found in a roughly triangular area that includes the coal fields of the Ruhr and the iron deposits of Lorraine and that tapers gradually westward to the seaport of Calais. While this great industrial triangle is cut by international boundaries, in normal times it functions as an economic unit in spite of tariff barriers and has a huge internal trade. This European industrial triangle is much like our Pittsburgh-Buffalo-Chicago triangle except that it has better access to the sea. From this area are shipped vast quantities of iron and steel and other manufactures to markets scattered throughout the world.

The Swedish Iron and Steel Industry. Sweden has long been famous for the quality of her iron ore, pig iron, and steel. As Sweden has very little coal and a limited domestic market, over 90% of her output of iron ore is exported, chiefly to Germany and Great Britain.[57] This trade is based upon one of the world's greatest reserves of high-grade magnetite ore, which is mined north of the Arctic Circle not far from the head of the Gulf of Bothnia. The largest deposit is at Kirunavaara, with an estimated reserve of 1.5 billion tons averaging 67.7% in iron content.[58] Large-scale production of these ores began in 1903 following the completion of an electric railway that connects the mines with the Swedish port of Lulea on the Gulf of Bothnia, which is closed by ice in winter, and with the ice-free Nor-

[55] Following World War I, French iron and steel production was stimulated by the acquisition of iron ore deposits and German-built iron and steel plants in Lorraine, by the construction of modern plants in the devastated areas of the North, by the temporary receipt of reparations coal and coke from Germany, and by economic control of the Saar Basin until 1935.

[56] The iron-ore deposits of Luxemburg are an extension of the Lorraine field, which provides 95% of the imported ore. These ores have a high phosphoric content, and about 94% of the steel output of Belgium-Luxemburg is produced by the basic Bessemer process. In contrast with northern France, where the open-hearth process is dominant, pig iron, rather than scrap, is the chief raw material in steel-making.—U. S. Tariff Commission, *op. cit.*, pp. 180, 181, 216, 225.

[57] For the last 40 years, Germany has taken over 70% of Swedish iron ore exports, and Great Britain, about 10%. Other markets include Czechoslovakia, the United States, and Belgium. In 1938 12,485,000 tons of ore were exported.

[58] These ores average 0.026% in phosphoric content and require basic steel-making processes.—*Ibid.*, p. 167, and Olin R. Kuhn, *op. cit.*, pp. 85, 87.

River in the Apennines, most of the nation's steel is produced at Genoa and other industrial centers of the North in open-hearth furnaces which are vitally dependent upon coal and coke imported from Germany and Great Britain and upon huge importations of iron and steel scrap. Iron and steel manufacturers have received much governmental aid, and in 1938 the industry achieved a record output of 2,700,000 tons of steel.

9. *The New Russian Iron and Steel Industry*

The Remarkable Progress of Russia. No modern nation has built up a great iron and steel industry and achieved such outstanding industrial progress in so short a time as has Soviet Russia. Since the change of government in 1917, all basic industries have been owned and operated by the state in accordance with a nationwide system of economic planning. From the beginning it was realized that a large iron and steel industry was necessary to supply the nation with armament for its defense and to provide industrial machinery, railway equipment, farm machinery, and many other products needed for the economic development of the country. Between 1913 and 1939 the Russian steel output increased from 4 to 19 million tons, and since 1931 Russia has ranked third among the iron and steel producing nations of the world. In contrast with other European countries, at the outbreak of World War II Russia was self-sufficient in all the basic materials of steel-making: coal, coke, iron ore, limestone, pig iron, scrap metal, manganese and most ferro-alloys. Indeed, by 1937 domestic plants were manufacturing 98% of all the finished iron and steel products consumed in Russia.[60] This remarkable development of iron and steel production was accomplished by the mechanization of coal and iron mining, by the modernization and expansion of long established iron and steel plants, and by the exploitation of iron and coal reserves together with the creation of new iron and steel manufacturing centers in the Ural Mountains and in Siberia far removed from the danger of military invasion.[61] The development of the iron and steel industry, in conjunction with many other forms of manufacturing, in so short a time involved a terrific cost in blood, sweat, toil, privation, and countless Russian rubles. The military wisdom of this industrial expansion was amply demonstrated by the performance of the Russian armies during World War II, and its ultimate benefit in years to come will be to raise the standard of living of the Russian people.

The Donetz Basin. The southeastern part of the Ukraine has long been the leading steel-making district of Russia. In the Donetz Basin (Donbas) are large deposits of excellent coal, and 250 miles to the west near Krivoi Rog are ores that average 68½% in metallic iron, with a large deposit of high-grade manganese only 50 miles away. Hence, the large-scale manufacture of iron and steel has been developed at Stalino and other cities in the Donetz Basin and at Krivoi Rog, with an exchange of coal, coke, and iron ore between the two areas similar to that of the Ruhr and

[60] U. S. Tariff Commission, *op. cit.*, p. 270.

[61] See George B. Cressey, "Siberia's Role in Soviet Strategy," *Jl. of Geog.*, vol. 41, March, 1942, pp. 81-88.

Lorraine. Other steel-making centers have arisen at Berdyansk, Mariupol, and Taganrog along the north shore of the Sea of Azov and also in the Crimea, where iron deposits are mined near Kerch. At the outbreak of World War II, the Ukrainian district produced over one-half of the nation's iron and steel and supplied most of the iron and steel products needed in the Moscow-Gorki, Ukrainian, and Leningrad industrial areas.[62]

Magnitogorsk and the Ural Industrial Area. Fortunately for Russia, manufacturing had been developed on a large scale in the southern part of the Ural Mountains area, with an important iron and steel industry at Magnitogorsk, before the invading German armies approached the gates of Moscow and Leningrad and swept across the Ukraine. Probably no area was ever industrialized in the face of greater difficulties and with such rapidity.[63] In 1929 Magnitogorsk did not exist; three years later it was a booming city of 200,000 inhabitants when its first blast furnace began production; by 1938 it and other Siberian centers were manufacturing nearly one-third of the nation's iron and steel; and by the end of 1941 its plants were turning out more than 5,000 tons of pig iron and 6,000 tons of steel a day. On Christmas Day of 1943 there was a great celebration in Magnitogorsk when its sixth blast furnace, built entirely of Russian materials, was completed after five months of strenuous labor. This Russian Pittsburgh obtains its iron from a deposit of 275 million tons of high-grade magnetite ore at Magnitnaya a few miles away. At first it was necessary to transport all coal and coke 1,400 miles by rail from the Kuznetsk Basin (Kuzbas) of west central Siberia, but this expense was greatly reduced when good coal was discovered at Karaganda, 600 miles to the southeast of Magnitogorsk. In 1938 Magnitogorsk obtained 85% of its coal supply from Karaganda, 8% from the Kuznetsk Basin, and the remainder from deposits of mediocre grade in the Urals.[64] Only a few miles from the city is a large deposit of manganese, which has been mined since 1934. While iron and steel are now manufactured at Nizhni Tagil, Chusovaya, and other secondary centers, Magnitogorsk is indeed the hub of the Ural industrial area. Its products have helped to create and serve the machine shops, railway shops, and electrical equipment industry at Sverdlovsk, the oil refineries and Diesel engine works at Ufa, the airplane motor factories at Perm, the chemical industry at Usolye and Berezniki, the machine tool and tractor plants at Chelyabinsk, and the mining districts scattered throughout the Ural Mountains.[65] During World War II the Ural industrial area was transformed into a huge arsenal that saved the life of the nation.

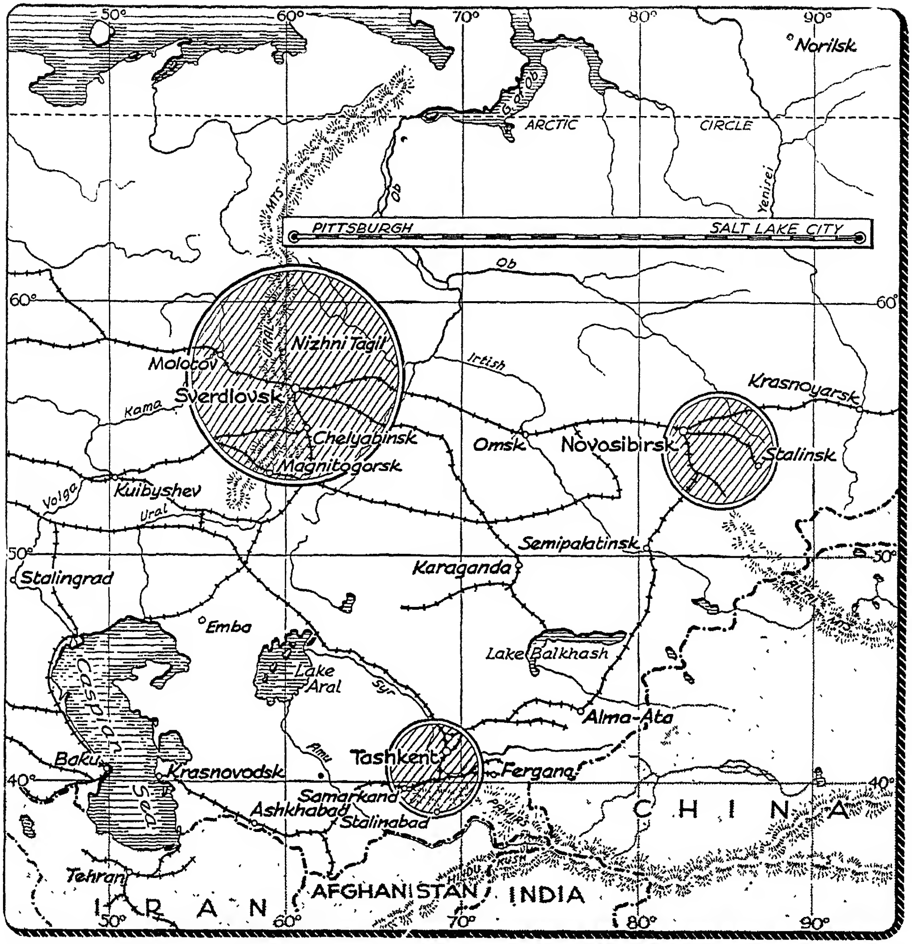
Siberia. While the greatest industrial development in Siberia has occurred along its western edge in the Ural area,

[62] At the outbreak of the war, these three areas accounted for 58% of Russia's entire industrial output, as compared with 90% in 1930, which indicates the progress of the plan to develop manufacturing in the Ural, Siberian, and Turkestan areas.

[63] See John Scott, *Behind the Urals,* Houghton Mifflin Co., Cambridge, Mass., 1942.

[64] *Ibid.,* p. 262.

[65] Mineral production includes coal at Kizel, chromite near Orsk, nickel at Kalilovo and Ufalei, copper at Kyshtym, magnesium at Berezniki, zinc near Chelyabinsk, bauxite at Kaminsk, petroleum near Ufa, salt at Usolye, potash at Solikamsk, and pyrites at Blyava and Krasnouralsk.



Map of Siberia. The major industrial areas of western Siberia and Russian Central Asia. The products of these industries caused Hitler to exclaim in astonishment as the Russians mowed down the German armies with equipment that was not supposed to exist.

which lies nearest to the old and large population centers of European Russia, the government has done much to establish manufacturing in the interior and far eastern regions in an effort to make them more self-sufficient and to raise the standard of living of the inhabitants. The manufacture of iron and steel has been developed at Leninsk-Kuznetski and Stalinsk in the Kuznetsk Basin, which apparently has coal reserves five times larger than those of the Donetz Basin.[66] About 125 miles south of the steel-making centers are important deposits of iron ore, the exploitation of which has contributed to

[66] About 84% of the coal reserves of the Soviet Union are in Asia, and those of the Kuznetsk Basin are estimated at 450 billion tons. Between 1913 and 1940 the Kuznetsk coal output increased from about 2,800,000 to more than 25,000,000 tons.—*Ibid.*, p. 261, and U. S. Tariff Commission, *op. cit.*, pp. 265-266.

the decline of the exchange of Magnitogorsk iron and Kuznetsk coal. Although Novosibirsk, the chief city in this region, increased in population from 120,000 in 1926 to 426,000 in 1939 largely as a result of the development of manufacturing, the chief handicap to the Kuznetsk iron and steel industry is the present limitation of the market. This same handicap applies to steel-making centers at Irkutsk near Lake Baikal, Khabarovsk in the Amur Valley, and other places that make use of local deposits of coal and iron. In general it may be said that Siberia has two great needs, more railroads and more people. In time the government will build the railroads, and more Soviet citizens will be persuaded to take advantage of Siberian opportunities.[67]

10. Iron and Steel Manufacturing in the Orient

The Japanese Iron and Steel Industry. A century ago Japan was an isolated feudal kingdom. In 1900 the country had little modern industry and only primitive establishments for the manufacture of iron, yet by the outbreak of World War II Japan had achieved remarkable industrial progress and ranked sixth among the steel-making nations of the world in spite of her poverty in coal and iron.[68] The iron and steel industry of modern Japan had its origin at the port of Yawata on the island of Kyushu when the Imperial Steel Works, with an annual capacity of 90,000 tons, was completed by the government in 1901. From the beginning, the industry was regarded as an indispensable sinew of war and was fostered and dominated by the government. Private enterprise has operated with difficulty in spite of lavish subsidies, high tariffs, tax exemptions, long-term loans at low interest rates, and other favors bestowed by the government. Indeed, in 1937 about 90% of all pig iron and 50% of all steel manufactured in Japan came from government owned or operated plants.[69] The result of large and continuous governmental expenditures is shown by the increase of the steel output of the Japanese Empire from only 240,000 tons in 1913 to 2,290,000 tons in 1930, and to 6,340,000 tons in 1939.

During the nineteen-thirties the coal mines of northern Kyushu, central Hokkaido, and the Heijo (Pyengyang) district of Korea were able to meet over 90% of the nation's coal requirements, but domestic coal is unsuitable for coking purposes unless high-grade coal is mixed with it. Hence, Japan had to import coking coal, most of which came from the Kaiping mines of North China.[70] Although iron ore is mined in northeastern Honshu near Kamaishi, in northeastern Korea, and from smaller deposits elsewhere, domestic ores are low in iron content, mining costs are high, and reserves are so pitifully small[71] that the empire was forced to

[67] Of the thousands of workers who arrived at Magnitogorsk, about one-fourth did not come of their own free will.—John Scott, *op. cit.*, p. 73.

[68] See John E. Orchard, *Japan's Economic Position*, McGraw-Hill Book Co., Inc., New York, 1930, and Kate L. Mitchell, *Japan's Industrial Strength*, Alfred A. Knopf, New York, 1942.

[69] U. S. Tariff Commission, *op. cit.*, p. 281.

[70] Satisfactory metallurgical coke is made by mixing Chinese and Japanese coal in the ratio of one to four.—*Ibid.*, p. 290.

[71] The combined reserves of Japan and Korea are estimated at 80,000,000 tons. Less than half of these are in Japan proper, and they would be inadequate to operate the American iron and steel industry for one normal year.—*Ibid.*, p. 286.

import more than three-fourths of its iron ore supply. The imported ores, averaging more than 60% in iron content, came chiefly from British Malaya, China, the Philippines, and Australia, and their cost when delivered in Japan was usually less than that of local ores. However, imports of 3 or 4 million tons a year did not satisfy the needs of the Japanese steel-making centers, and throughout the nineteen-thirties Japan was the world's largest importer of pig iron and iron and steel scrap, depending upon foreign sources for about one-third of its pig iron and over one-half of its scrap. The pig iron was obtained chiefly from British India and from Japanese-owned blast furnaces in Manchuria, while the United States provided nearly all of the imported scrap. Furthermore, the empire obtained most of its alloy materials from foreign sources, over one-half of its manganese ore supply being imported from Manchuria, Malaya, and the Philippines. In view of Japanese dependence upon imported materials, it is not surprising that the manufacture of iron and steel in Japan is located almost entirely at seaboard, Yawata and Kamaishi being the leading centers.

While disturbed political conditions prevailing in the Far East since Japanese troops invaded Manchuria in 1931 make it difficult to appraise the Japanese iron and steel industry, this much can be said. Japan stands in sharp contrast with the nations of western Europe, where private enterprise has been highly successful in developing iron and steel manufacturing dependent upon imported materials. Japan also stands in sharp contrast with Russia, where the government has created a truly great iron and steel industry based upon huge domestic resources. The Japanese iron and steel industry must be regarded as a political and military creature that has been established upon a weak economic foundation, and its future, like that of Germany, lies under the fiat of victors in war.

Manchuria and China. On the eastern Asiatic mainland the principal development of iron and steel manufacturing has occurred in Manchuria, where it has been promoted by heavily subsidized Japanese companies. About four-fifths of all pig iron is manufactured by the Showa Steel Works at Anshan, located along the South Manchurian Railway between Mukden and the port of Dairen. This plant, established in 1917, obtains its ore from the Kungchuling iron mines nearby, most of its coal from Fushun, and its coking coal from Penhsihu. The Penhsihu Coal and Iron Co. mines iron ore at Miao-erh-kou and smelts it in blast furnaces that were established in 1911 at Penhsihu along the railroad between Mukden and the port of Antung. Both companies export pig iron to Japan, but the Showa concern converts most of its pig iron into steel, chiefly for consumption in Manchuria. Although Manchuria has large coal reserves estimated at 4 to 20 billion tons, iron ore reserves amount to less than 375,000,000 tons, and most of the ore contains much silica and less than 36% of metallic iron.[72] Hence, the ore must be crushed, roasted, and concen-

[72] It is said that the recently developed Tungpientao deposits of eastern Manchuria contain 100,000,000 tons of rich (60% to 65%) iron ore and several hundred million tons of low-grade ore in close proximity to coking coal.—Kate L. Mitchell, *Industrialization of the Western Pacific*, Institute of Pacific Relations, New York, 1942, p. 87.

trated prior to smelting, which makes the cost of pig iron high.[73] In spite of the fact that Manchuria came to be completely dominated by Japan through the establishment of the puppet Government of Manchukuo in 1932, the output of 762,000 tons of pig iron and 427,000 tons of steel in 1937 was far below Japanese expectations.[74]

In contrast with the small but modern iron and steel industry operating in Manchuria at the outbreak of World War II, similar industrial development was almost nonexistent in China proper. While hundreds of little primitive foundries manufactured simple articles for common use, only two blast furnaces were in operation, and steel production was confined to a few small plants in Shanghai that turned out castings and bars for the local market. The blast furnaces, one near Hankow and one at Yang Chuan in Shansi, had a combined capacity of only 120 tons a day and operated intermittently because of high production costs and the difficulty of securing regular supplies of coke from distant sources in North China.[75] Prior to the invasion by the Japanese armies, China usually imported about 400,000 to 500,000 tons of iron and steel products from the United States, western Europe, and Japan, and exported about a million tons of iron ore a year to Japan from mines located near Hankow and Wuhu along the Yangtze River. Although rich in coal and materials for making alloys, China has iron reserves that apparently are too small to support a great iron and steel industry.[76] Indeed, political stability must be established, and overland transportation must be greatly improved before any considerable industrial development can be achieved. Perhaps the best chance of developing a sizable iron and steel industry in eastern Asia will involve the joint utilization of Chinese coal and coke and rich Philippine iron ore, with ocean vessels providing cheap and easy transportation.[77]

Iron and Steel Manufacture in India. Among the Oriental nations, India is singularly fortunate in having one of the world's largest and richest deposits of iron ore in close proximity to large deposits of coal, adequate coking coal, and abundant limestone. These are found in the provinces of Bihar, Orissa, and western Bengal, only 125 to 200 miles west of Calcutta, India's greatest city and seaport. The coal reserves are said to amount to over 10 billion tons, and the iron ore deposits are easily worked by open-pit methods and are

[73] See U. S. Tariff Commission, *op. cit.*, pp. 282-283, and Daniel R. Bergsmark, *Economic Geography of Asia*, Prentice-Hall, Inc., New York, 1935, pp. 556-558.

[74] See Kate L. Mitchell, *op. cit.*, p. 84.

[75] *Ibid.*, p. 117, and U. S. Tariff Commission, *op. cit.*, p. 302.

[76] The most liberal recent estimates credit China with less than 1 billion tons of ore, three-fourths of which is located in Manchuria. The actual iron content of these reserves could not operate the American iron and steel industry for nine years. —George B. Cressey, *China's Geographic Foundations*, McGraw-Hill Book Co., Inc., New York, 1934, pp. 118-119, and U. S. Tariff Commission. *op. cit.*, p. 301.

[77] See Erich W. Zimmermann, *op. cit.*, pp. 661, 664. Philippine reserves are estimated at about 800 million tons, ranging from 47% to 65% in metallic iron. The largest deposits, averaging 54%, are located along the seacoast of northern Mindanao and may be exploited by open-pit methods. The only deposits now being mined are those at Mambulao, Camarines Norte, in eastern Luzon; these contain not less than 5,000,000 tons of ore, averaging 61% in iron content.—William H. Haas (ed.), *The American Empire*, The University of Chicago Press, Chicago, 1940, pp. 338-339, and U. S. Tariff Commission, *op. cit.*, p. 262.

even better than those of our Lake Superior district, as they contain about 3 billion tons of ore ranging from 60% to 69% in iron content.[78] With cheap labor and easy access to fuel and raw materials, this district produces the cheapest pig iron in the world, and for some years prior to World War II India was the leading exporter of pig iron, shipping 30% to 40% of its output abroad, chiefly to Japan, Great Britain, and the United States. At Jamshedpur the Tata Iron & Steel Co. operates a monster iron and steel plant, which in prewar years produced 70% of the country's pig iron and all of its steel.[79] This company began operations in 1911 and was developed entirely by Indian capital and initiative. Although domestic plants achieved a record output of 2,000,000 tons of pig iron and 1,250,000 tons of ingot steel in 1941, India manufactures less than 1% of the world's iron and steel and must normally import about 30% of its supply of finished steel products. Unquestionably, India has vast mineral resources and a potential market that could support a much larger iron and steel industry. Unfortunately, India has long suffered from arrested industrial development caused by British economic policy which through tariff schemes has endeavored to promote the production and exportation of foodstuffs and raw materials needed in Great Britain and to preserve the huge Indian market for British manufactures, protecting them against the competition of both Indian and imported foreign goods.[80] Not until after the outbreak of World War II did British authorities make a belated and strenuous effort to develop heavy industries that were sorely needed to supply Allied armies in the Asiatic theater of war.

11. Developments in Australia, Canada, and Latin America

Unless the iron and steel industry of a nation is blessed with easy access to abundant and suitable coal and iron and to a large and growing industrial market, its development is seriously handicapped. Although many nations have artificially stimulated the manufacture of iron and steel by tariffs and subsidies, no nation has developed a big and strong industry where the coal-iron-market combination is deficient or lacking. The experience of Australia, Canada, and Latin America further illustrates this basic truism of modern iron and steel making.

Australian Developments. Australia has coal, iron, and 7,142,000 people. It has had a modern iron and steel industry since 1915, when the Broken Hill Proprietary Co. began the manufacture of pig iron, steel ingots, and finished

[78] Charles H. Behre, Jr., "India's Mineral Wealth and Political Future," *Foreign Affairs*, vol. 22, October, 1943, pp. 82-85, and Olin R. Kuhn, *op. cit.*, p. 89. The total coal reserves of India have been variously estimated at 20 to 70 billion tons, and the iron ore reserves, at 3 to 23 billion tons.

[79] Other establishments in this area include the blast furnaces of the Indian Iron & Steel Co. at Burnpore and Kulti and the steel works and rolling mills of the Steel Corporation of Bengal, which began operations at Hirapur in November, 1939. At Shimoga in northwestern Mysore the provincial government operates a few charcoal furnaces using wood obtained from the government-owned forests.

[80] See Vera Anstey, *The Economic Development of India*, Longmans, Green & Co., London, 1942, pp. 5-10; and Kate L. Mitchell, *op. cit.*, pp. 275-291. It should be noted that similar colonial policies have been pursued far more vigorously by other Great Powers. Such is the stuff from which wars are brewed!

steel products at Newcastle.[81] Since 1921 the government has levied high import duties with the result that the country's output of ingot steel increased from about 220,000 tons in 1921 to 1,169,000 tons in 1939, domestic plants producing about 85% of all steel consumed in Australia. Iron and steel plants at Newcastle, Port Kembla, and Lithgow, along the coast of New South Wales, utilize high-grade coal from nearby mines and obtain rich iron ore that is transported cheaply by ocean vessels from the Iron Knob field near the port of Whyalla[82] on Spencer Gulf in South Australia and from distant little Koolan Island in Yampei Sound along the northwest coast of Western Australia. While Australia is well endowed with coal, its iron ore reserves are not large, and its domestic market is indeed limited. In view of these limitations and Australia's remote location in reference to large foreign industrial markets, no great expansion of Australian iron and steel production can be anticipated, although it is reported to have the largest single steel plant in the British Empire.

Canada's Two Steel-making Districts. The Canadian market (pop. 11,507,000) is served largely by two steel-making districts that have developed under the stimulus of bounties and high tariffs.[83] One center has arisen at Sydney, Cape Breton Island, Nova Scotia, which is surpassed only by Birmingham, Alabama, in its ease of access to the materials of steel manufacturing. Along the Straits of Belle Isle in Newfoundland is the famous Wabana iron ore deposit, containing not less than 4 billion tons of ore, ranging from 48% to 57% in metallic iron. Iron ore and limestone are shipped cheaply by water from Newfoundland to iron and steel works at Sydney, on Cape Breton, which lie within a few miles of mines that produce excellent coal. Finished steel can be sold to the cities of the upper St. Lawrence Valley, but unfortunately the American tariff wall stands between Sydney and the large industrial markets of New England. Another steel-making district has arisen at the Lake Ontario ports of Hamilton and Toronto, which obtain all of their iron ore from American mines near the head of Lake Superior[84] and which import their coal and coke from Pennsylvania. The iron and steel plants of this district primarily serve the factories of Ontario, many of which owe their existence to the protection offered by the Canadian tariff. At one time (1854-66) Canada and the United States enjoyed the advantages of complete freedom of trade, and it is a pity that tariff barriers separate these good neighbors, which in so many ways are dependent upon each other.

[81] This company held a monopoly until 1927-28, when the Australian Iron & Steel Co. began to expand the output of its Port Kembla plant, but in October, 1935, the two firms were consolidated, and competition was eliminated.—Kate L. Mitchell, *op. cit.*, p. 253.

[82] The Iron Knob deposits are slightly richer than those at Kirunavaara, Sweden, but they contain only one-fifteenth as much ore.—Olin R. Kuhn, *op. cit.*, pp. 87, 90. In May, 1941, a blast furnace with a daily capacity of 700 tons began the smelting of iron ore at Whyalla.

[83] Outright bounties were paid for the production of pig iron from 1883 to 1911 and for steel from 1896 to 1913. The Canadian steel output increased from 20,000 tons in 1895 to 1,040,000 tons in 1913, and to 1,940,000 tons in 1940.

[84] Late in 1942 operations were under way to drain Steep Rock Lake, about 100 miles north of the Mesabi Range in Canada, in order to start mining on the bed of the lake which is said to cover 32 to 500 million tons of iron ore.—"Little Mesabi," *Time*, November 16, 1942, pp. 85-86, 88.

Latin America. On January 1, 1944, the combined capacity of all Latin American steel-making plants, including those under construction, was only 1,400,000 tons, or less than the actual prewar output of Canada or Australia or Poland.[85] All of the Latin American nations, with the possible exception of Colombia, are very deficient in coal, and most of the available supply is of inferior quality. Only Brazil and Cuba, and possibly Mexico, have large reserves of iron ore, and prior to 1944 only Chile and Cuba were able to export iron ore in considerable quantities.[86] No Latin American country has more than an infant iron and steel industry, although Mexico, Brazil, Argentina, and Chile have developed manufacturing of great local importance through the medium of tariff protection. In Latin America, as elsewhere, consumers must usually pay the bill for such industrial progress, since industries that actually require protection have high costs and must charge higher prices for their products than would prevail under the impact of foreign competition.

Brazilian Possibilities. Brazil has the largest known iron ore reserves in the world, estimated to contain from 7 to 15 billion tons of ore.[87] The largest deposit, which is now being developed, contains 3½ billion tons of ore that ranges from 63% to 69% in metallic iron and is located at Itabira, Minas Gerais, about 200 miles west of the port of Vitoria. The railroad to Vitoria has been reconditioned to handle heavy traffic, mining machinery is being installed in the Itabira area, and it is expected that about 1½ million tons of ore will be mined annually. An iron and steel plant is under construction at Volta Redonda in the Paraiba Valley between Rio de Janeiro and São Paulo, which are Brazil's largest industrial centers. Unfortunately, Brazilian coal reserves are apparently small, and most of the coal is of inferior grade, being high in ash content. The best coal available, which can be made into coke, is mined 40 miles inland from the port of Tubarao in Santa Catarina, about 600 miles south of Rio de Janeiro, and it is planned to use this coal in the manufacture of iron and steel at Volta Redonda.[88] The entire development is being financed with funds provided by the Brazilian and American governments and expenses have enormously outrun estimates. While this rising iron and steel industry will loom large in Brazilian economy, it seems likely that most of Itabira's great heap of iron ore eventually will be consumed in American or European steel-making centers. Meanwhile the Brazilians will pay high prices for their tariff-protected steel.

12. World Trade and the Future

In our modern era of cheap and efficient transportation, the trade in iron and steel virtually encircles the globe. Iron ore is now shipped from Australia

[85] American Iron & Steel Institute, *Steel Facts,* No. 62, November, 1943, p. 4.

[86] In prewar years about 1,500,000 tons of Chilean iron ore were exported annually, chiefly from El Tofo mines via the world's largest sea-loading ore dock at Cruz Grande. About 200,000 tons of Cuban ore were exported from mines near Santiago. Both of these mining districts are owned and operated by the Bethlehem Steel Corpn., which transports the ore in its own vessels to its plants along our eastern seaboard.

[87] *Ibid.* and Olin R. Kuhn, *op. cit.,* p. 86.

[88] See Preston E. James, *Latin America,* The Odyssey Press, New York, 1942, pp. 465-466, 529, and W. Robert Moore, "Brazil's Potent Weapons," *The National Geographic Magazine,* vol. 85, January, 1944, p. 60.

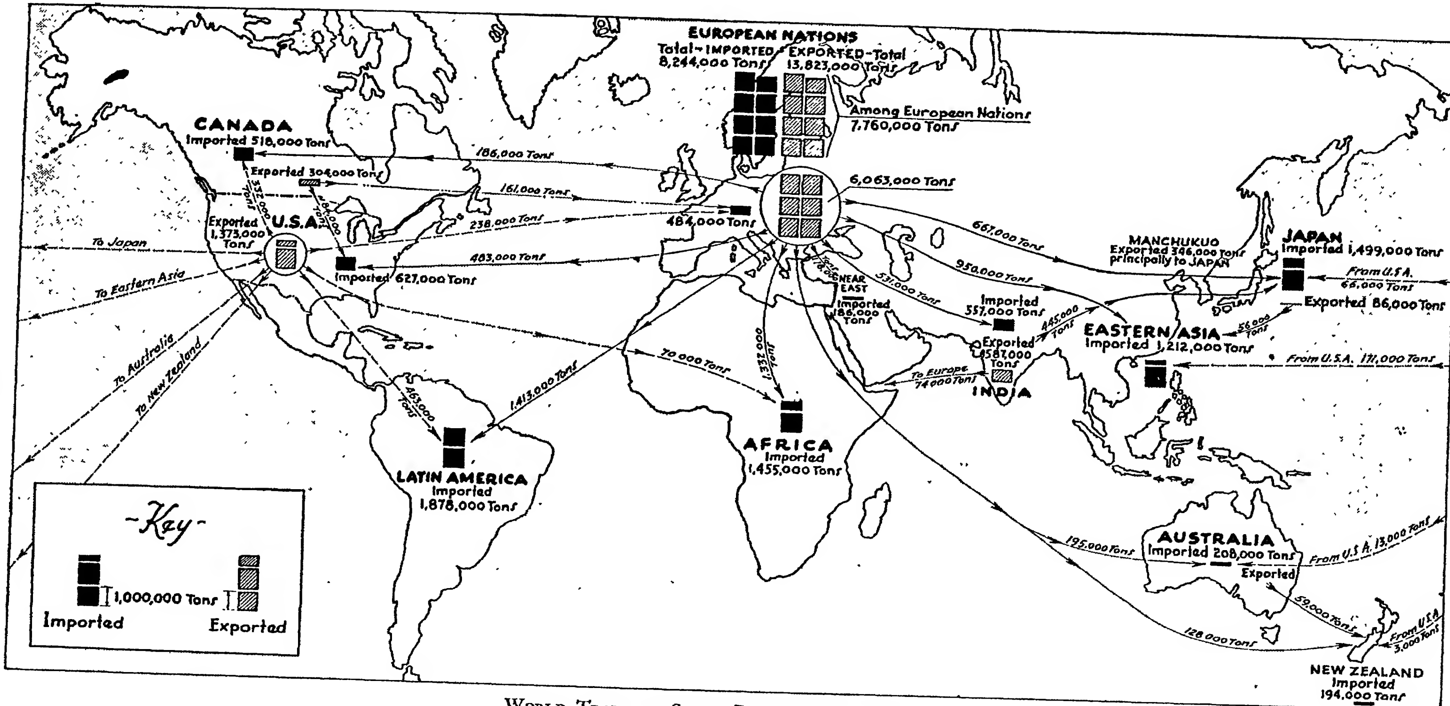
and Chile to steel-making plants on the eastern American seaboard, pig iron moves from India to Japan and Great Britain, while finished steel products have long been exported from western Europe and eastern America to almost any point in the world where man is engaged in production and trade. From the great iron and steel manufacturing plants of Great Britain, and later from the plants of America and western Europe, have come vast quantities of steel rails, bridges, girders, heavy machinery, and other productive equipment, together with countless consumers' goods, for use by the peoples of every land. Yet in spite of the scope, cross-currents, and complexities of this worldwide trade, a few salient features may be observed.

The Movement of Iron Ore. On the raw material side, it may be noted that only 30% of the iron ore that is mined each year actually enters the channels of international trade.[89] This is simply due to the fact that the United States mines nearly all of the iron ore that it needs, that Russia is self-sufficient, and that all of the other great steel-making countries except Japan are important producers of iron ore. Hence, the bulk of the world's international trade in iron ore moves toward the western European steel-making countries that are inadequately supplied with ore. Germany, Belgium-Luxemburg, and Great Britain are the markets for about four-fifths of this international movement of iron ore. France and Sweden are the leading exporters of iron ore, largely because they lie near to ore-needy countries and are unable to consume their large domestic supplies. From France and Sweden come about three-fifths of the world's total exports of iron ore, the remainder being shipped from a large number of widely scattered sources. It should be emphasized that iron ore is a cheap, heavy, and bulky commodity that cannot stand high transportation costs. While it can move nearly halfway around the world cheaply in ocean vessels, it seldom moves more than 300 miles overland. Hence, water transportation plays a big role in both domestic and international trade. Without the cheap transportation afforded by the American Great Lakes, by the rivers and canals of western Europe, and by the great ocean highway, the assembly of most of the world's iron ore for manufacture would be stymied indeed.

The Movement of Iron and Steel Manufactures. Iron and steel manufactures, because of their greater value, can stand much higher transportation costs than iron ore; they travel much farther overland, and they are shipped to some of the world's most remote continental interiors. In the prewar decade Germany, Belgium-Luxemburg, Great Britain, France, and the United States were the world's leading exporters of finished and semi-finished products of steel.[90] There is always a large trade among the countries of western Europe, Germany and Great Britain importing semi-finished steel from France and Belgium-Luxemburg, subjecting it to further manufacture, and consuming or exporting the finished products. Most of the exports from Germany, Belgium-

[89] U. S. Tariff Commission, *op. cit.*, p. 68, and Charles K. Leith, James W. Furness, and Cleona Lewis, *op. cit.*, p. 65.

[90] India, France, and Holland were the leading exporters of pig iron.



World Trade in Steel Plant Products, 1936

This map probably contains surprises. We in the United States have the production but we do not have the export, one reason being our high tariff level of prices. Note the large trade between European countries. They export more to each other than to all other countries. Note the export from Australia to New Zealand and from India and see a cause for the plight of northwestern Europe.

Luxemburg, and France are destined for European markets, although large shipments are made overseas. Most British exports, however, find markets outside of Europe, especially throughout the vast British Empire. Of the iron and steel products exported from the United States in 1940, 44.8% were shipped to Great Britain, 11.4% to Canada, 5% to Japan, 4.7% to Argentina, 3.3% to Brazil, and 2.8% to the Union of South Africa. In prewar years the small but growing exports of Japan were destined almost entirely for Japanese-dominated areas in eastern Asia. In contrast with the other great steel-making countries, Russia needs her iron and steel at home.

The Future. Despite the many shiftings of the iron industry it has as yet used but a small fraction of the total ore supply. The amount of ore throughout the world is very great, some of it being of good quality, but much the greater quantity is of relatively low grade such as we have not as yet learned to use because we have not as yet been compelled to do so. The iron industry, being comparatively young, has thus far drawn only upon the best ores.

Better and cheaper methods of smelting are also a future probability. The electric smelting of iron ore has long been experimented with, has reached a profitable stage, and has made rapid progress in recent years. This possible emancipation of iron making from a fuel supply is a matter of great significance. The Norwegians make a ton of iron per year for one horsepower of electric energy.

Perhaps a string of West Indian isles may each have a plant producing 500,000 kilowatts or twice that, of electric energy generated by engines boiling ether at 75° F. with surface water, and condensing it at 45° F. with subsurface water. That might become the world's greatest smelting center. Compare the huge oil refineries of Curaçao and Aruba, Dutch West Indies.

Successful iron making in the future is likely to depend more on superior equipment and machinery than on natural advantages. While the best Lake Superior ores are richer than those of Europe, the average quality is already declining, the cost of mining is increasing, and the distance of the ore from fuel and from blast furnace is often greater than in Europe. The lead of the United States in iron and steel manufacturing has been maintained largely through the use of wonderful ore-handling equipment and modern furnaces, many of them the best in the world. This lead may be overcome in the future when other countries begin to substitute modern machinery for man labor in every stage of iron making from digging the ore to turning out the finished steel.

7

Copper: Ancient and Versatile Metal

1. The Usefulness of Copper

Copper: the Handmaiden of Electricity. Although copper is one of the oldest of metals in the service of man, it has "grown up" with the electric dynamo very much as iron and coal grew up with the steam engine and as petroleum achieved its maximum development with the advent of the internal combustion engine. With the exception of silver, copper is the best conductor of electricity known to man, it resists corrosion, it is easily drawn into fine wire, and it is comparatively cheap. Hence, copper became the handmaiden of electricity and has proved indispensable to the generation, transmission, and use of electric power. Indeed, about one-half of all copper consumed in the United States each year is associated with the use of electricity. Among the thousands of devices that depend upon the electrical conductivity of copper are the light bulb, mechanical refrigerator, air conditioning apparatus, telegraph, cable, telephone, radio, electric locomotive, railway signal equipment, and the ignition system of every automobile. The spatial significance of the copper wire in modern communication is revealed by the fact that the earth is belted with 30,000 miles of submarine cables and by more than 7,000,000 miles of telegraph wire, while the world's 43,000,000 telephones are linked together by 180,000,000 miles of wire that would be long enough to extend 773 times the distance from the earth to the moon.

The Antiquity of Copper. More than 7,000 years before modern man utilized copper to usher in the present era of electricity, Neolithic man discovered that the "red metal" had useful qualities that were far superior to those of wood, bone, and stone for making tools, weapons, ornaments, and various utensils. Copper is malleable, and man found that lumps of native copper, obtained from surface outcrops, could be hardened and brought to a fine edge by hammering. The metal has a low melting point, and the quantity available for use was greatly increased when someone discovered that copper could be easily smelted from its ore. Later it was found that copper fuses readily with tin to make bronze and with zinc to make brass.[1] Both bronze and brass are far more durable than copper, and bronze holds a much sharper cutting edge. Bronze proved useful in so many ways that primitive man was able to emerge from the Stone Age into an advanced stage of civilization that has been aptly called the Bronze Age. While nobody knows when man first used copper,

[1] The first dirty bronze products were undoubtedly the result of accidental melting of copper and tin which sometimes occur in the same vein of ore; likewise, copper and zinc were alloyed to form brass. Many generations must have transpired before man deliberately manufactured bronze and brass. Today the copper content of brass exceeds 50%, while that of bronze is seldom less than 80%.

archaeological excavations have uncovered copper objects made prior to 4000 B.C. in Mesopotamia and Egypt, and we know that bronze was produced in the Near East about 2500 B.C. It is generally believed that the stone-copper-bronze cycle occurred in Europe about 2000 B.C. and about the same time in China and India, but it did not evolve among the Aztecs of Mexico and the Incas of Peru until about the beginning of the Christian era.[2]

The ancient world achieved great proficiency in the working of copper, bronze, and brass, and to this day we do not know how ancient artisans were able to temper copper into a good cutting tool. About 2000 B.C. Hissarlik was a flourishing bronze-making center on the shores of the Dardanelles, although it later became more famous as the besieged city of Troy, immortalized by Homer through the episode of the wooden horse. From Hissarlik Cretan traders carried swords, spears, hooks, scythes, and other articles of bronze for sale throughout the Mediterranean area and up the ancient Danube trade route into Bohemia, Saxony, and Silesia.[3] In the early years of the Roman Empire well organized factories at Capua turned out articles of copper, bronze, and brass, each bearing the name of the producer. These factories involved a large capital investment, and they employed thousands of workmen and made extensive use of division of labor. Skilled metallurgists melted the copper, carefully mixing it with tin or zinc, while others specialized in forging, carving, polishing, and other tasks. So excellent was the quality of the output that Cato advised his readers to buy bronze buckets, containers for wine, oil, and water, and all other copper ware made at Capua.[4] Bronze lamp stands, tables, braziers, tripods, and other metal furniture produced at Capua have been found in the ruins of Pompeii. Ancient artisans were able to cast in bronze enormous statues far more beautiful than most of the so-called objects of art that clutter our public parks and buildings today. Copper, bronze, and brass were also used at various times for coinage, the "widow's mite" of Biblical fame being made of copper.

Modern Uses. The useful properties of copper, so well known to the ancients, continued to serve man down through medieval and modern times, and many new applications have been found for this old and versatile metal. Of the copper consumed in this country each year, more than one-tenth is utilized by the automobile industry for non-electrical purposes, and another tenth is employed by the construction industry for roofing material, water pipes, and other uses. Copper, bronze, and brass are extensively used in shipbuilding, and a single steam locomotive may contain more than 3 tons of copper.[5] Furthermore, copper is cast into bearings, bushings, lubricators, valves, and fittings; it is alloyed with iron and nickel in the production of stainless steel, with nickel to make monel metal,

[2] See L. F. Salzman, "Metals," *Encyclopaedia of the Social Sciences*, vol. 10, The Macmillan Co., New York, 1933, pp. 364-365, and William Y. Elliott and others, *International Control in the Non-Ferrous Metals*, The Macmillan Co., New York, 1937, pp. 389-390.

[3] *Ibid.*

[4] See Tenney Frank, *An Economic History of Rome*, The Johns Hopkins Press, Baltimore, 1927, pp. 236-237.

[5] John G. Glover and William B. Cornell (ed.), *The Development of American Industries*, Prentice-Hall, Inc., New York, 1941, pp. 431-432.

and with aluminum to make duralumin; and it enters into the manufacture of steam radiators, clocks, watches, locks, and many other things. While each passing year witnesses a greater diversity in the use of copper, its prime function today is in the service of electricity. Indeed, it was chiefly the demand arising from the phenomenal growth of the electrical industry, together with modern improvements in mining, smelting, refining, and fabrication of the metal, that caused the world's production of copper to increase from 173,000 tons in 1880 to 1,100,000 tons in 1913, and to more than 2,500,000 tons in 1940. Copper today undoubtedly ranks second only to iron as a necessary industrial metal.

2. *The Occurrence and Mining of Copper*

Nature and Occurrence of Copper. Copper is of igneous origin, and while it is occasionally found in a metallic or "native" state,[6] it usually occurs in chemical combination with other elements in the form of an ore such as a sulfide, oxide, chloride, or carbonate. Frequently other metals, such as gold, silver, nickel, tin, lead, and zinc are found in the same body of ore, these valuable by-products being recovered in the process of smelting and refining. Sometimes copper itself is a by-product of mining; as in Canada, where about half of the annual copper output is a by-product of nickel mining. Copper ore may be found in rich veins or pockets, or it may be disseminated throughout a great mass of rock or earthy material, called gangue, which must be excavated along with the ore and later separated from it. In contrast with iron ore which ranges from about 30% to over 60% in metallic content, most copper ore that is mined today contains less than 3% copper, few ores exceed 6%, while American ores now average less than 1½%. Indeed, huge bodies of disseminated ores with a metallic content of only 1% to 2%, known as porphyries, may actually contain far more metal than concentrated richer veins, and it may be noted that the world's largest copper reserves in northern Chile consist of such low-grade porphyry ores. Because of the chemical and physical differences in copper ores, a 1% ore in one form may be profitable, while a 3% ore in another form may be worthless. Furthermore, a copper deposit may be located at or near the surface or far underground, and it may be near the market or thousands of miles away. Hence, the profitability of copper mining depends not only upon the metallic content of the ore but also upon its accessibility, chemical composition, and the feasibility of extracting the copper.

The Shift from Selective to Mass Mining Methods. In spite of increased mechanization of mining, the production of copper throughout most of the nineteenth century was impeded by the crude concentrating and smelting methods that made it necessary to restrict mining activity to veins or pockets that would yield rock high in copper content. If any considerable amount of poor ore and waste rock was mixed with good ore, the recovery of copper

[6] Native copper is pure copper that can be easily extracted from any rock material associated with it. Only in Michigan has the mining of native copper been of economic importance.

was too low to yield a profit. Therefore, it was necessary to practice careful "selective" mining, which involved the tedious separation of pay ore from poor ore and waste rock by hand. This restriction on mining largely explains why the world's output of copper increased slowly from about 18,000 tons in 1800 to only 52,000 tons in 1850, and to 173,000 tons in 1880. It also goes far to explain why England with its rich Parys and Mona mines in Anglesea led the world in copper production throughout the first half of the century,[7] why Chile with its rich Tamaya ores achieved leadership as English reserves dwindled, and why the unusually high-grade Michigan copper became the sensation of the century and helped the United States in the eighteen-eighties to become the world's foremost producer.[8]

Toward the end of the nineteenth century, technological improvements made it possible to concentrate and smelt ore of lower grade at a profit. No longer was the miner forced to grub painstakingly along the pay streak, watching every crumb of ore. Instead, the miner could extract all mineralized rock and send it to the concentrating mill and smelter, which handled the problem of selection and recovery. With the advent of non-selective, mass mining methods, production costs were greatly reduced, and today it is possible to utilize nearly all of the ore found in veins or pockets and also to exploit the low-grade porphyry ores such as those in Utah, Arizona, Nevada, and northern Chile.

While copper-mining methods vary considerably in different parts of the world, the increasing use of power-driven machinery has continuously reduced the amount of manual labor required and has enabled man to pursue pay ore deeper and deeper into the bowels of the earth. As in iron mining, both underground workings and open-pit methods are used. The deepest mine in this country is the old Quincy copper mine near Hancock, Mich., where shafts penetrate the earth to a depth of more than 6,600 feet, and the largest open-pit copper mine is at Bingham Canyon, Utah, where a mountain 2½ miles long and half a mile high is being blasted and shoveled away.

3. *The Technology and Location of Manufacture*

The Concentration of Copper Ore. On its way from mine to market, copper usually moves through the processes of concentration, smelting, converting, refining, and fabrication before it is ready to meet the needs of consumers.[9] The concentrating mill is located in close proximity to the mine, because

[7] The average yield of English ore was 12.7% in 1772, 9.3% in 1800, 7.8% in 1850, and about 6.6% between 1870 and 1885. England had no large deposits of low-grade ore to use after its limited high-grade reserves were depleted.—William Y. Elliott and others, *op. cit.*, p. 374.

[8] Commercial mining of the rich native copper deposits of Michigan began about 1845. In the early 1880's the American industry was dominated by the Calumet & Hecla Mining Co., which worked Michigan ore averaging 20% in copper content.—*Ibid.*, p. 393.

[9] The treatment of copper ores is characterized by a multiplicity of processes that are carefully adapted to the properties of individual ores.—See Erich W. Zimmermann, *World Resources and Industries*, Harper & Brothers, Publishers, New York, 1933, pp. 682-687; Evan B. Alderfer and Herman E. Michl, *Economics of American Industry*, McGraw-Hill Book Co., Inc., New York, 1942, pp. 81-84; and John G. Glover and William B Cornell (ed.), *op. cit.*, pp. 425-428.

the ore is generally mixed with large amounts of heavy, worthless rock and earthy material that can be transported economically only a few miles. This mine mixture is crushed, screened, and sorted mechanically and is then washed by a current of water across oscillating trays that catch and retain the heavier mineralized particles, or concentrates, which are high enough in copper content to be ready for the smelter. The refuse from the water concentration process contains much copper, so it is ground into a fine powder and put into a tank containing oil and water, which are agitated to a froth and then allowed to settle. The copper-bearing particles adhere to the oil at the surface, while the refuse settles and is drawn off from the bottom of the tank. The copper concentrate is easily separated from the oil and is dried and sent to the smelter. This froth flotation process, which was discovered in 1905 and first used in Australia, was one of the great triumphs in the technological advancement of the industry, for it brought about a much more effective recovery of copper and the use of low-grade ore that formerly had no commercial value.[10]

If the ores are sulfides, they may be sent from the concentrating mill to a roasting furnace, which eliminates much of the sulfur and oxidizes many of the impurities prior to smelting. On the other hand, oxide ores are usually treated by leaching. The crushed ore is placed in a large vat, sometimes holding more than 10,000 tons, and a sulfuric acid solution[11] percolates down through the ore and leaches out the copper in the form of a copper sulfate solution. This is run into electrolytic tanks, where an electric current, flowing through the solution from insoluble anodes, deposits copper on cathodes. After the cathodes are built up with sufficient copper, they are sent to the smelter to be purified and cast into commercial shapes.

The Smelting and Converting Processes. In the process of smelting, additional impurities are removed either in blast furnaces or reverberatory furnaces. In the copper blast furnace the concentrated ore is mixed with limestone and coke and is treated in about the same way as is iron ore in the production of pig iron. On the other hand, reverberatory smelting employs a furnace that operates much like the open hearth in steel making. In recent decades it has very largely displaced the blast furnace, which is not adapted to handle the finely pulverized concentrates produced by the flotation process. Indeed, at the outbreak of World War II, reverberatory furnaces provided 94% of the total smelting capacity of the United States.[12] The product of the smelter is known as copper matte, which has an average metallic content of 40% to 50% but which may contain 60% copper or more. Since copper concentrates are usually too low in value per unit of bulk to stand the costs of long-distance transportation, smelters are generally located in the mining district near the concentrating

[10] The froth flotation process is satisfactory for the treatment of an ore from which only copper is to be recovered. Later this was developed into a selective or differential process, which uses various oils or chemicals to recover silver, lead, zinc, and other metals from complex ores.

[11] The sulfur obtained from roasting furnaces and smelters can be made into cheap sulfuric acid.

[12] Evan B. Alderfer and Herman E. Michl, *op cit.*, p. 83.

mill at some point that has access to limestone and coke.[13]

Closely associated with smelting is the process of converting copper matte into blister copper, which is about 99% pure.[14] As a rule, copper matte is conveyed in the molten state by ladles from the smelting furnace to the converter, which operates like a Bessemer converter in the manufacture of steel. Because of its purity and greater value in proportion to bulk, blister copper can obviously be transported longer distances than 60% copper matte, just as 20% to 40% matte can move farther than copper concentrates or ore.

Refining and Fabrication. Blister copper contains minute quantities of the baser metals, such as lead and zinc, which must be removed if the copper is to be used by the electrical industries. It also contains precious gold and silver that are well worth recovering.[15] Hence, blister copper is sent to a refinery, where the principle of electrolysis is employed to remove the last impurities and to build up cathode plates of virtually pure copper.[16] These cathodes are then melted in reverberatory furnaces and are cast into various shapes, which are ready for fabrication. Since high-grade matte and blister copper can be transported economically long distances, refineries do not have to be located near the raw material. A seaboard refinery has the obvious advantage of cheap water transportation and is able to obtain its raw material cheaply from a variety of sources. Indeed, most of the world's copper refineries occupy coastal locations in proximity to great markets and abundant supplies of cheap electric power, although some important refineries are found at interior points in or near copper mining areas. About 70% of the refining capacity of the United States is located between New York and Baltimore.

Copper is shipped from the refinery in forms that are convenient for manufacture. Thus, copper destined for wire-drawing mills is shipped in wire bars with pointed ends to facilitate the entry of the bars into the first set of rollers. If copper is to be remelted in crucibles to make copper castings or to manufacture brass, bronze, or other alloys, it is shipped from the refinery in deep-notched ingot bars that can be easily broken into small parts that will fit readily into crucibles. Billets up to 6 inches in diameter are shipped to tube mills. Slabs and square cakes of various sizes go to rolling mills, where sheets, strips, bus bars, etc., are the final products, but circular cakes are needed for the manufacture of seamless, cylindrical products such as tanks and kettles. The final step in the manufacture of copper occurs when these various shapes are fabricated by the metal-working establishments. In the United States about

[13] A smelter that can draw upon several sources of ore is obviously in a better position to operate continuously, and a few seaboard smelters, near big industrial centers, specialize in the treatment of imported copper concentrates.

[14] The product is called "blister copper," because air bubbles escaping from the cooling metal cause blisters to appear on the surface.

[15] Every ton of refined copper has an average yield of 0.009 fine ounces of gold and 0.414 fine ounces of silver.—Evan B. Alderfer and Herman E. Michl, *op. cit.*, p. 84.

[16] Electrolytic refining has nearly displaced the older method of refining by the use of high temperatures in reverberatory furnaces. In this country the furnace process is used only in Michigan. Since 1900 the New York price of electrolytic copper has been the standard market quotation, while in London fire-refined copper remains the standard, electrolytic copper being quoted separately.

70% of all copper is used in the manufacture of producers' goods,[17] and consequently the copper industry is vitally dependent upon the continued industrial growth of the market and suffers greatly during periods of business depression.

The Importance of Secondary Copper. Since it is cheaper to remelt and refine copper scrap than to dig ore and extract the metal and since copper alloy scrap can be fabricated anew without breaking it down into its component parts, secondary copper has come to be of increasing importance. The long-run trend is shown by the fact that 34% of the total output of American refineries in 1941 consisted of secondary copper, as compared with 28% in 1925 and only 12% in 1910. Of our total production of 726,000 tons of secondary copper in 1941, about 57% was derived from old scrap gathered from junk piles and other sources throughout the country, the remainder being obtained from new or industrial scrap that was discarded by factories and mills. Indeed, in years of business depression, when prices are low and many mines are shut down, secondary copper assumes even greater importance, as in 1933-34 when the amount of copper recovered from old scrap in the United States actually exceeded that produced from domestic ores.[18] While the growing supply of scrap and man's increasing ability to use it mean greater competition for copper mining companies, it is good from the viewpoint of conservation that this durable metal can be recovered and used again and again.

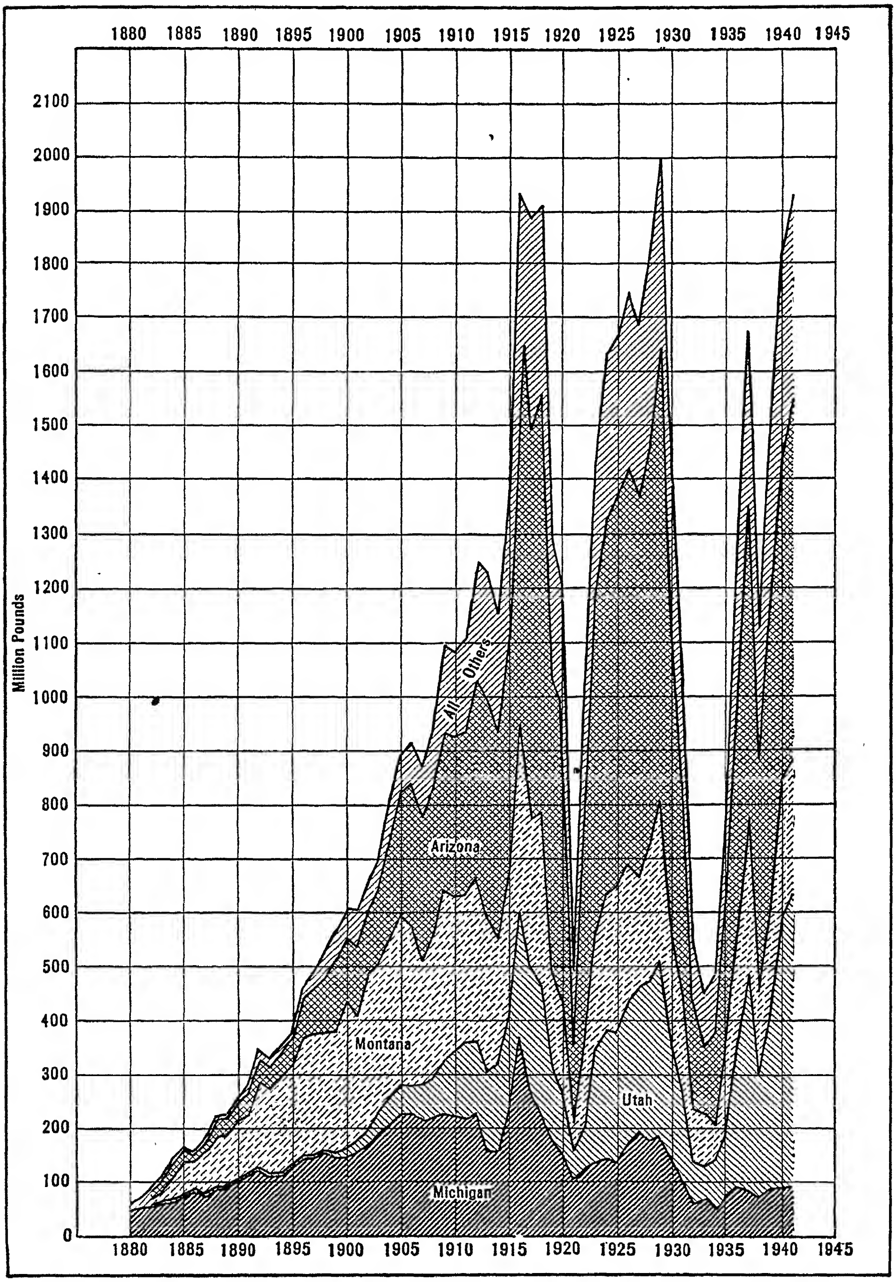
4. *The Westward Migration of American Copper Production*

Growth of American Copper Production. The development of American copper production during the last hundred years was an integral part of the westward expansion of the nation. As railroads penetrated the West, as new and important deposits were discovered, as the new technology made lower-grade ores available for use, copper production moved westward, and the nation's output greatly increased. As in the exploitation of most of our mineral resources, we began by skimming the "cream" and later turned to recovering the thinner but more voluminous "milk," for the expansion of American copper production was based upon the successive development of the unusually high-grade copper of Michigan, the less rich veins of Montana, and the low-grade porphyry ores farther west. From a minuscule yield of about 750 tons in 1850, or less than 1½% of the world's supply, the nation's production increased to 30,000 tons in 1880, 303,000 tons in 1900, 605,000 tons in 1920, and 966,000 tons in 1941.[19] Since 1883 the United States has been the world's premier producer of copper, and from 1894 to 1928 American mines maintained an almost continuous record of producing more than a half, and at times two-thirds, of the world's total output. In

[17] William Y. Elliott and others, *op. cit.*, p. 380.

[18] The production of secondary copper from both old and new scrap amounted to 177% of the domestic mine output in 1933, 159% in 1934, and 76% in 1941.

[19] These data represent smelter output from domestic ores. Maximum production of 1,001,000 tons was achieved during the boom year of 1929. —Charles K. Leith, James W. Furness, and Cleona Lewis, *World Minerals and World Peace*, The Brookings Institution, Washington, 1943, pp. 217-218.

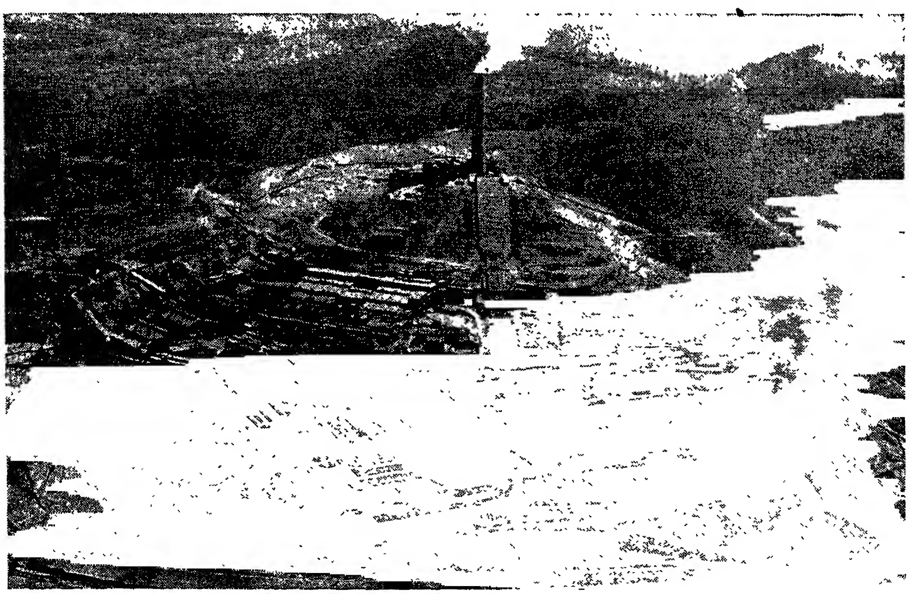


The fluctuations of copper production exceed even those of iron and steel. There are several reasons. It is used for new construction, even more exclusively than is steel. Also in time of depression and low price, we are shut out of foreign markets because the Chilean roto, the Mexican peon and the Belgian Negro work for so much less than the highly paid American.

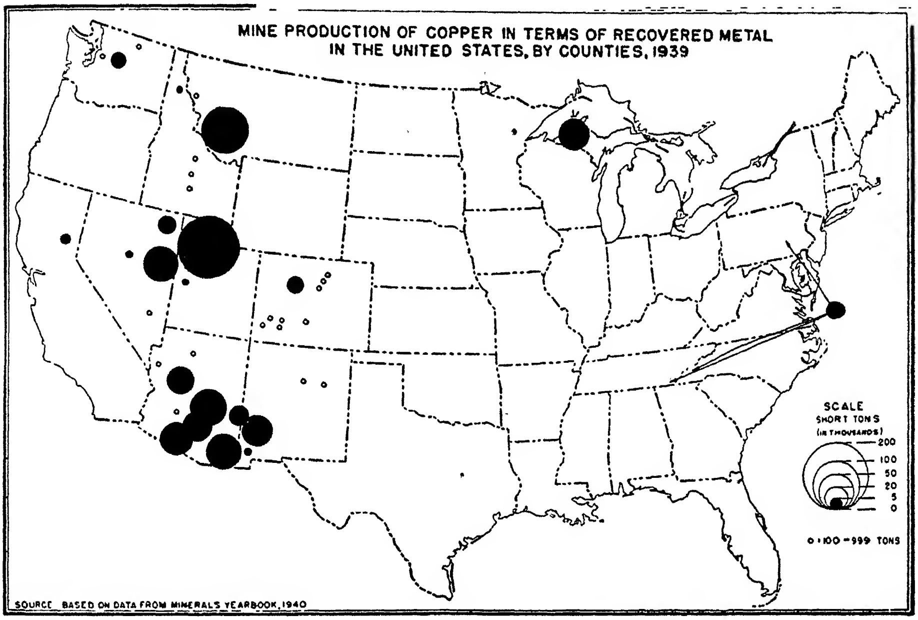
recent years, however, the growth of foreign production has caused a decline in the relative importance of American copper, which at the outbreak of World War II amounted to about one-third of the world's supply.

The Pioneer Michigan Copper District. From 1845 to 1887 the Upper Peninsula of Michigan was the leading copper mining district of the United States, its early development being stimulated by its relative nearness to market, by the cheap transportation afforded by the Great Lakes, and by the exceptional purity of its copper.

In the old rocks of this glaciated district are large copper deposits, unusual in that some of them consist of native or pure metallic copper. Unfortunately, many of the masses are often too large to be taken out whole. Thus, one single chunk, weighing 540 tons, had to be chiseled by hand into smaller pieces. However, the use of diamond drills and other modern devices has eliminated much of this manual labor, and shafts have been sunk deep into zones where copper occurs in smaller masses, some mines being more than a mile deep. Because of its purity, the copper of this district does not require electrolytic refining but is treated simply in furnaces at Hubbell and Houghton that obtain their coal and coke cheaply via the Great Lakes. While from 1845 to 1880 Michigan produced 75% to 85% of the nation's copper, today its share is less than 5%, and its output is exceeded by that of three western states (see Fig. 191). Occasionally the high prices of boom times stimulate output, but the old mines of Michigan are confronted



The lone miner may still go out and get a bit of gold by himself in some places, but not copper—look what it takes. At the top of the hill a smokestack near 500 feet high was built to get deadly smelter fumes out of the way of man, animals and plants. Gases are carried up the slope in a covered tunnel from the center of the picture to the base of the smokestack. Anaconda Copper Works, Butte, Montana.



Mines at Bingham Canyon and Butte stand out gloriously on this map. Certainly the western half of our country is the copper half, and the deserts of Arizona and the Great Basin shine while the copper lasts.

with diminishing productivity, which is the fate of all mining industries.

The Butte Copper District. In 1882 a huge deposit of copper was struck in a hill at Butte, Montana, as the result of a search for silver, and five years later Montana became the leading copper producing state. At the present time ore is hoisted from the mines at Butte and is shipped 26 miles by rail to Anaconda, where it is concentrated, smelted, and converted into blister copper.[20] From Anaconda the blister copper moves to an electrolytic refinery at Great Falls, where cheap hydro-electric power is available. Today the great hill at Butte is pierced by more than a hundred shafts, some of them 4,100 feet deep, and in times of high prices about 10,000 miners, working in 2,700 miles of underground passages, send 20,000 tons of copper and zinc ores to the surface every 24 hours. Since the beginning of mining operations, the Butte district has yielded over 6 million tons of copper, or about 21% total output of the United States.

The Prolific Porphyry Ores of Arizona, Utah, and Nevada. While copper mining in Arizona began in the early eighteen-seventies with the development of the Morenci district, which was soon followed by other discoveries, mining at first was confined to the richest deposits, and it was not until 1907 that Arizona turned to non-selective mass mining of

[20] As the huge amount of water needed for large-scale concentration and smelting is not available in the vicinity of the mines, the reduction works are located at Anaconda.—*Cf.* Erich W. Zimmermann, *op. cit.*, p. 683, and Harold H. McCarty, *The Geographic Basis of American Economic Life*, Harper & Brothers, Publishers, New York, 1940, p. 194.

Clyde Anderson

Bingham Canyon, Utah. In this huge landscape, it appears that a large part of the surface is being shoveled up and hauled away. The landscape is so huge that the town, a row of houses seven miles long, strung out in the canyon, is almost invisible. The vast work required to move such a low-grade ore, concentrate it, smelt it, is another evidence of the heavy capital required for copper mining, especially in the low-grade ores.

low-grade porphyry ores.[21] In 1907 supremacy in output passed from Montana to Arizona, which, with a single exception in 1909, has retained leadership to the present day. Arizona mines have proved to be the most prolific in our copper history, yielding 9,500,000 tons of copper or about 33% of the nation's output to date. Such mining towns as Globe, Bisbee, Jerome, Ajo, and Morenci are almost entirely dependent on the red metal, which is more valuable per capita to the sparse population of Arizona than is wheat in North Dakota or coal in Pennsylvania. When the copper is gone the towns will

[21] Although the Morenci deposit was originally developed on the basis of selective mining, it came to be operated with non-selective steam-shovel methods. Some porphyries in Arizona lie well beneath the surface and require shaft mining, a system of "block-caving" being used.—William Y. Elliott and others, *op. cit.,* pp. 373, 541, 543.

die, as many western mining towns have already died.

America's pioneer porphyry mine and our greatest copper mining district of today is at Bingham Canyon, Utah, a few miles south of Great Salt Lake. Although the ores of this district average only 1.07% in metallic content, they contain more than 6.8 million tons of copper and comprise the largest known copper reserve in North America.[22] Open-pit mining operations began in 1907, and today giant electric shovels continue to bite into the mountain of copper, electrified trains hauling the ore to concentrating mills nearby. At Garfield the concentrates are roasted, smelted, and converted into blister copper, which is then ready for shipment to eastern refineries. Since 1927 Utah has ranked second among our copper producing states, virtually all of its copper being mined in the Bingham district, which in 1941 had an output of 265,000 tons, or more than twice that of Butte. About 150 miles southwest of Bingham Canyon is another huge porphyry deposit at Ely in eastern Nevada, which in recent years has had an annual yield of 60,000 to 70,000 tons.[23]

Refining and Fabrication in the East. While refineries now operate at Great Falls, Mont., El Paso, Tex., Inspiration, Ariz., and Tacoma, Wash., the great bulk of refining and fabrication remains entrenched in the East.[24] Today the output of approximately 200 mines moves through 16 smelters and 9 refineries en route to final manufacture. Furthermore, it should be noted that the American copper industry is dominated by four large companies, as 75% of the nation's mining capacity is owned by the Kennecott Copper Corporation,[25] and 85% of the refining capacity is controlled by the American Smelting & Refining, Anaconda, and Phelps-Dodge interests. Thus, while copper production has migrated into the West, the purse-strings of the industry are held by the stockholders and bondholders of the East.

5. South American Developments

The Great Copper Hill at Chuquicamata. The Pacific coast of South America is rich in copper deposits, many of which were mined in a small way by the Indian long before the coming of the white man. The world's largest-known copper reserves are found in Chile,[26] which now ranks second among all nations as a producer and first as an exporter of copper. Greatest of Chilean deposits is Chuquicamata, situated in the Desert of Atacama on the slopes of the Andes about 10,000 feet above sea level and connected by railroad with

[22] Percy E. Barbour, "World Copper Reserves," *Engineering and Mining Journal,* vol. 135, October, 1934, p. 449.

[23] The reserves at Ely, with a copper content estimated at 4.4 million tons, rank second among North American deposits.—*Ibid.*

[24] Eastern electrolytic refineries are located at Laurel Hill, N. Y., at Barber, Carteret, and Perth Amboy, N. J., and at Baltimore, Md. In Michigan furnace refineries are in operation at Houghton and Hubbell, and another at Hancock has been idle since 1933.

[25] The ownership of extensive copper deposits in Chile and Mexico gives Anaconda a total productive capacity about equal to that of Kennecott. —Evan B. Alderfer and Herman E. Michl, *op. cit.,* p. 86.

[26] The world's total reserves are estimated to have a copper content of 104.8 million tons, of which 35.5 million tons are located in Chile. The Chuquicamata deposit is known to contain 1,000 million tons of ore, but its owners have never made a final estimate of the ultimate reserves.—Percy E. Barbour, *op. cit.,* pp. 448-449.

the ports of Antofagasta and Mejillones. Chuquicamata Hill, covering an area of 2½ by ⅓ miles, is so thoroughly mineralized that the entire mass is considered to be workable ore, which unquestionably is the greatest heap of copper known to man. The face of the hill is being blasted off at different levels, and the ore moves in trainloads sometimes at the rate of 50,000 tons a day to the concentrating mills nearby. As this porphyry deposit consists of oxide ores, averaging 2.2% in copper content, the concentrates are converted into blister copper by means of the leaching process and electrolysis. Mining operations began in 1915, and today Chuquicamata is a well-established community of 15,000 people in spite of the fact that everything must be imported, for the desert offers no water, no food, no fuel, and no building materials.

The remarkable development of Chuquicamata is a striking illustration of the fact that the conversion of a potential resource into an actual resource is frequently the result of a propitious combination of many factors.[27] It was purely accidental that the Bolivia and Antofagasta Railway had been previously built within 5 miles of the copper hill. In 1911, when a staff of experts was sent to investigate the property, it was found that the ores could not be worked by any method known at the time, an obstacle that was soon overcome by the perfection of a new process involving leaching and electrolysis. In the building of the Panama Canal, engineers learned how to use steam shovels in a big way, knowledge that proved indispensable at Chuquicamata. Fortunately the canal was completed in 1914, thereby providing the west coast of South America with much shorter routes to eastern United States and western Europe. The power problem was solved by constructing an electric generating plant, using Californian and Peruvian petroleum as fuel, at the port of Tocopilla and by erecting high-voltage lines to conduct the power 100 miles across the desert to Chuquicamata. The water supply had to be piped from Andean streams 80 miles away. The problem of labor supply was solved by hiring unemployed workers from the desert's nitrate fields, by importing labor from the Central Valley of Chile, and by bringing in engineers, chemists, and other technical experts from the United States. Such a huge project called for a large expenditure of capital funds, and during World War I and the postwar era Europe had no capital to spare, but the necessary millions of dollars were readily obtained in the United States. Finally, it should be noted that Chuquicamata was developed at a time when the world demand for copper was increasing rapidly and prices were spiraling upward.

Other Chilean Developments. Another Chilean copper mining district is found in the southern part of the desert at Potrerillos about 90 miles east of the port of Chañaral. Here, too, many difficulties had to be surmounted before its lean ores, averaging only 1½% in copper, could be successfully mined. A third district, which at times yields one-fourth of the nation's output, lies high in the Andes at El Teniente, about 60 miles southeast of Santiago. Some 2,500

[27] See Erich W. Zimmermann, *op. cit.*, pp. 674-676, and Ray H. Whitbeck and Frank E. Williams, *Economic Geography of South America*, McGraw-Hill Book Co., Inc., New York, 1940, pp. 192-197

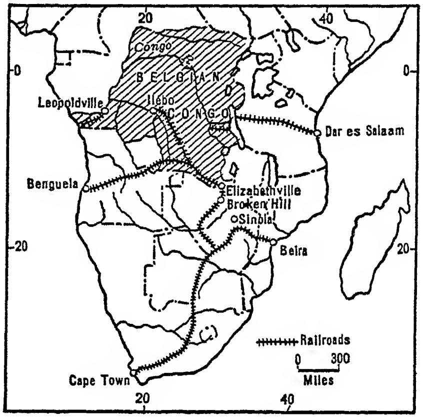
oxen were used to haul in the original mining equipment, and the heavy snowstorms of the region made it necessary for the company to build miles of snowsheds to protect its railroad connecting the mines with the main railroad at Rancagua. In this district shaft mining methods are used, and blister copper is shipped to foreign markets through the port of Valparaiso. These developments at El Teniente, Potrerillos, and Chuquicamata owe their very existence to American initiative and capital.[28]

Peruvian Copper. Peru is also a source of copper, chiefly through the output of the Cerro de Pasco district upon the high Andean Plateau. This section was at one time dependent on pack trains, but now sends its product to the sea by means of the railroad that passes through Lima to Callao. Peruvian copper is mined largely in conjunction with silver, lead, zinc, and bismuth.

Elsewhere in South America copper mining is of minor commercial importance in the Corcoro district of Bolivia and at Famatina in the Andes of Argentina. Little-known deposits are reported in Venezuela and Colombia.

6. *Copper in Africa*

The Rich Ores of Katanga. In recent times the Belgian Congo and Northern Rhodesia have come to rank among the world's great producers of copper as the result of the exploitation of a rich copper belt, approximately 280 miles long and 50 miles wide, extending southeastward through the Katanga district of the Congo into adjacent Rhodesian territory.[29] As the accompanying map reveals, at least two-thirds of this copper belt lies in the Belgian Congo (see Fig. 197). The ores of the Katanga district



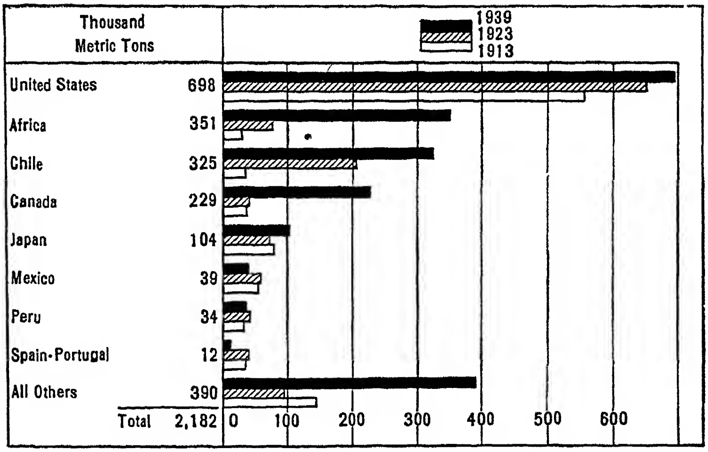
Africa is no longer an unexplored land of mystery. These railroads that help to make Africa second among continents in copper production have helped to cause African minerals to be the basis of its first entry into modern world trade in a really large way.

are oxides with an average copper content of 6½%, some of them running as high as 25%, while those of Northern Rhodesia are chiefly sulfide ores averaging 3½% in metallic content. However, the lower-grade sulfides of Northern Rhodesia are easier to smelt, and the deposits are said to contain 3½ times as much copper as those of Katanga.[30]

[28] More than $60,000,000 is invested in the property at El Teniente, which is owned by the Braden Copper Co., and controlled by Kennecott interests. More than $220,000,000 is invested in Chuquicamata and Potrerillos, the former being owned by the Chile Copper Co. and the latter by the Andes Copper Co., both of these firms in turn being controlled by Anaconda.

[29] See Ralph E. Birchard, "Copper in the Katanga Region of the Belgian Congo," *Econ. Geog.*, vol. 16, October, 1940, pp. 428-436, and Walter Fitzgerald, *Africa*, E. P. Dutton & Co., Inc., New York, 1939, pp. 218-219, 284-291.

[30] The copper content of Northern Rhodesian ores is estimated at 22.4 million tons, as compared with 6.5 million tons in the Katanga district. In contrast, the Chuquicamata deposit contains 94% as much copper as is known to exist in all of Africa.—Percy E. Barbour, *op. cit.*



This graph of copper production is another evidence of the almost overwhelming riches of the United States in natural resources in the machine age.

Since 1932 Northern Rhodesia has surpassed Belgian Congo in copper production, and their combined output now exceeds that of Chile (see Fig. 198).

The mining of copper on a commercial scale began in the Katanga district in 1911 following the extension of a railroad from the south into Elisabethville and the construction of a smelter at Lubumbashi.[31] Nearly all of the present output is mined in areas that center about the towns of Elisabethville, Panda, Kambove, and Ruwe. With the exception of a single mine that has shafts about 1,000 feet deep, the deposits are easily worked by open-pit methods. Smelting operations have long been dependent upon imported coal, obtained chiefly from the Wankie mine in Southern Rhodesia but also from South Africa, Belgium, Germany, and Holland.[32] The entire mining district is now supplied with electricity from a hydro-plant at Cornet Falls on the upper Lufira River, and since 1930 a smelter and electrolytic refinery have been in operation at Panda. All of the Katanga output is now exported in the form of electrolytic copper, blister copper, or high-grade matte.

Northern Rhodesia. This part of Africa was long considered an unpromising field, since the oxidized outcrops of ore occurred in narrow bands and averaged about 3% to 5% in metallic content, and it was not until the late nineteen-twenties that Rhodesian potentialities became apparent.[33] By the end of 1930 it was established that the Northern Rhodesian field held 500,000,000 tons of ore containing more than 20,000,000 tons of copper. Large-scale production began with the opening of the Roan Antelope mine in June, 1931, and other properties were developed soon afterwards at N'Kana, Mufulira,

[31] In 1906 the Belgian Government granted the Union Minière du Haut Katanga a concession to work an area of 7,776 square miles until 1990. This enterprise, financed by Belgian and British capital, has been interested not only in the mining of copper but also in the production of tropical fats and oils and in the exploitation of silver, tin, radium, cobalt, and other minerals.

[32] Ralph E. Birchard, *op. cit.*, p. 432.

[33] William Y. Elliott and others, *op. cit.*, pp. 414, 447.

and Rhokana. Concentrating mills and smelters were set up in these mining areas, and in 1935 an electrolytic refinery was completed at N'Kana. In 1940 the smelter output of Northern Rhodesia amounted to 231,000 tons, as compared with 149,000 tons in the Belgian Congo.

Because of its interior location, the Katanga-Rhodesian copper belt has from the beginning of operations been confronted with a serious transportation problem. The long and circuitous Congo River is an unsatisfactory transportation route, since its numerous falls and rapids make expensive transshipments necessary. When the Northern & Southern Rhodesian Railways extended their line to Elisabethville in 1910, the copper belt achieved economic access to the sea, and for the next twenty years most copper was shipped by rail to the Indian Ocean port of Beira in Mozambique (Portuguese East Africa), a distance of about 1,600 miles, although some copper moved over the still longer rail route to Capetown. In 1931 a new railroad reached the Katanga district from the Atlantic port of Benguela, Angola (Portuguese West Africa). This route is 1,300 miles long, and it judiciously follows the divide between the Congo and Zambezi Basins, thereby reducing the danger from floods and washouts, and reducing the bridge problem to a minimum. The Benguela route is a more direct route to western Europe and eastern United States than the Beira route, since the overland haul is about 300 miles shorter and since the 3,000-mile ocean voyage around the Cape of Good Hope is eliminated. Hence, most of the copper traffic now moves through the port of Benguela.[34]

Elsewhere on the continent, copper production of minor importance is found in the Union of South Africa, most of the output coming from the Messina mine in northern Transvaal.

7. *Canadian, Russian, and Other Developments*

Canadian Copper Mining Districts. Canada has been the world's third largest producer of copper since 1938, when its output surpassed that of Northern Rhodesia. More than a half of all Canadian copper is obtained from the famous deposit of nickel-copper ore owned by the International Nickel Co. at Sudbury, Ontario, a few miles north of Lake Huron. This deposit contains about three-fourths of the nation's copper reserves.[35] Although the ore averages about 2% in metallic content and occurs in veins deep beneath the surface of the earth, the recovery of both nickel and copper makes mining operations very profitable. While some of the district's output is shipped in the form of copper matte, the major portion is refined in the company's refinery at Copper Cliff. About one-sixth of Canadian copper is mined in Quebec, chiefly in the Noranda district near the Ontario border. All of Quebec's output is refined at Montreal, which has ready

[34] An alternate route, 1,600 miles long, involves shipment via the Bas Congo-Katanga R.R. to Port Francqui, down the Kaisi and Congo Rivers to Leopoldville, and thence by rail to the port of Matadi near the mouth of the Congo. Another rail-and-water route extends to the port of Dar-es-Salaam in Tanganyika Territory, but it involves four transshipments of cargo and is used very little.

[35] Canadian reserves are estimated to contain 5.6 million tons of copper.—Percy E. Barbour, *op. cit.*, p. 449.

access to abundant hydro-electric power generated along the turbulent upper St. Lawrence. The remainder of the nation's copper is mined largely along the Manitoba-Saskatchewan border at Flin Flon, which has both smelting and refining facilities, and in British Columbia at Allenby and Howe Sound. Concentrates from the British Columbian mines are shipped to the nearby smelter and refinery at Tacoma, Wash., which also refines copper imported from Alaska, Lower California, and the west coast of South America. Most of the Canadian output is usually exported to the large industrial markets of Great Britain, Germany, and the United States.

Mexico and Cuba. In contrast with Canada and the United States, Mexico and Cuba are unimportant producers. The chief mining districts of Mexico are at Cananea, Sonora, an extension of the Arizona field, and at Santa Rosalia on the peninsula of Lower California. In recent years the copper industry has been retarded by the governmental policy of expropriating foreign-owned mining properties.[36] In Cuba the Matahambre mine in Pinar del Río is the leading producer, copper ore and concentrates being shipped cheaply by water to New Jersey for smelting and refining, but in recent years the Cuban output has been on the decline.

The Old Deposits of Europe. European nations, with the exception of Russia, play an unimportant role in copper production. A belt of low-grade pyritic copper stretches across Spain and Portugal where copper has been mined since Phoenician times, the famous Rio Tinto mines of southwestern Spain having been worked since 1240 B.C. In Germany most copper is produced by the old Mansfield mine, which has been exploited for over 600 years. With an annual output of less than 50,000 tons, Yugoslavia in prewar years was the leading European producer outside of Russia, most of its copper coming from the Bor mine, which was operated by a French concern.

Recent Developments in Russia. In Soviet Russia the remarkable expansion of industry during the nineteen-thirties was accompanied by an extensive development of power resources, a great increase in the production and use of electricity, and an ensuing increase in the demand for copper. To satisfy this growing demand, domestic copper production had to be supplemented by imports, and a big effort was made to locate and exploit new deposits. By 1939 Russia had become the world's fifth largest producer, its output surpassing that of the Belgian Congo. Whereas about three-fourths of all copper was mined in the Ural Mountains in the early nineteen-thirties, production thereafter expanded southeastward into Kazakhstan, which contains more than five-eighths of the nation's known reserves.[37] In recent years Kounrad and

[36] For years the Santa Rosalia deposit was worked by La Compagnie de Boleo, a French concern that imported all equipment, supplies, and fuel from Europe, but this property was expropriated in June, 1940.

[37] Total reserves are estimated at 1,390 million tons of ore, containing 16 million tons of copper. About one-fourth of the total reserves are in the Ural Mountains, approximately 70% of the Ural ores consisting of pyrites.—Guy C. Riddell and G. D. Jermain, "Russian Copper," *Engineering and Mining Journal*, vol. 135, December, 1934, pp. 547-551, and vol. 136, February, 1935, pp. 82-87. According to another estimate, the copper content of the world's leading reserves, in million tons, is as follows: Chile—35.5, Northern Rho-

Djezkazgan, to the north and west of Lake Balkhash, have become the leading copper-mining districts,[38] the large deposits of low-grade porphyry ores being easily worked with open-pit methods. Copper is also mined in the middle Volga region and on the Kola Peninsula. For years to come it is probable that the entire output of Russia will be needed at home.

Japan and Australia. With about 5% of the world's output, Japan is the leading copper producer in the Orient, but ever since World War I she has had to rely upon imports to satisfy her growing demand for copper. Although scores of small mines continue to operate, the bulk of the output comes from 5 mines on the island of Honshu,[39] Osaka being an important smelting and refining center. In Australia some copper is produced in Queensland and Tasmania. However, it may be said that, with the exception of Japan, copper production east of Suez is of minor importance.

8. *World Trade in Copper*

Major Participants in the Copper Trade. For more than 60 years the United States has played the leading role in the production and use of copper. This country is not only the world's greatest producer, our mines now yielding about one-third of the world's output, but American companies are the largest investors in the development of copper resources in foreign lands. Not only is this nation the world's largest consumer of copper, but it is the only large consumer that produces enough of the metal to meet domestic requirements. For years the United States has been a major participant in the world's copper trade, and it is now surpassed only by Chile in volume of exports and normally only by Great Britain and Germany in imports. About one-half of the world's copper is refined in the United States, and in 1936-40 our imports averaged 310,000 tons a year and were obtained chiefly from Chile, Canada, Mexico, Peru, and Cuba.[40] During this period our exports averaged 378,000 tons a year and were destined principally for Japan, Great Britain, Germany, France, and Russia.

It should not be assumed that American leadership has remained unchallenged. To the contrary, American copper in recent years has encountered the keenest sort of competition in foreign markets. Europe normally consumes over half of the world's copper, and in 1938 virtually all of the output of the Belgian Congo and Northern Rhodesia, over two-thirds of the Chilean output, and more than half of the Canadian output was sold to the copper-poor, industrialized countries of western Europe. However, American companies reap a profit from almost every ton of ore mined in Chile and from their large investments in other low-cost mining areas in many foreign lands. Furthermore, the American market has been protected since 1932 by an import duty of 4 cents a pound. If this tariff protection is necessary, it indicates that many

desia—22.4, United States—21.0, Russia 10.9, Belgian Congo—6.5, and Canada—5.6.—Percy E. Barbour, *op. cit.*

[38] George B. Cressey, "Siberia's Role in Soviet Strategy," *Jl. of Geog.*, vol. 41, March, 1942, p. 86.

[39] Glenn T. Trewartha, *A Reconnaisance Geography of Japan*, University of Wisconsin, Madison, 1934, pp. 64, 67.

[40] Because of wartime dislocations, Belgian Congo, which had not sold copper in the American market since 1930, became the second largest source of American imports in 1940 and 1941.

TABLE 16

PERCENTAGE OF WORLD'S TOTAL OUTPUT OF IMPORTANT MINERALS SUPPLIED BY LEADING PRODUCING NATIONS IN 1938

Mineral	*Largest producer*		*Second producer*	
Antimony *	Bolivia	27.0	China	24.2
Asbestos	Canada	57.2	Russia	18.7
Bauxite	France	17.7	Hungary	14.0
Chromite	Turkey	19.4	Russia	18.2
Coal and lignite	Germany †	26.2	United States ‡	24.4
Copper ore *	United States §	24.5	Chile	17.0
Flourspar	Germany †	35.2	United States ‡	17.2
Gas, natural	United States	88.5	Russia	3.5
Gold	Union of S. Africa	32.3	Russia	13.9
Gypsum	United States	26.7	Germany (1937)	19.0
Iron ore *	United States §	19.5	Russia	19.5
Lead ore *	United States	18.9	Mexico	15.9
Magnesium	Germany	57.1	Great Britain	12.1
Manganese ore	Russia	44.5	India	19.2
Mercury	Italy	44.4	Spain	28.0
Mica ‖	India	77.3	Madagascar	9.1
Molybdenum *	United States	92.4	Mexico	3.0
Nickel ore *	Canada	82.7	New Caledonia	10.1
Petroleum, crude	United States	61.1	Russia	10.5
Phosphate ¶	United States	26.1	Russia (1936)	13.8
Platinum	Canada	54.7	Russia	18.6
Potash **	Germany	58.9	France	18.4
Quartz crystal	Brazil	100.0		
Salt	United States	22.7	Russia (1936)	13.6
Shale oil	Estonia	34.5	Great Britain	32.1
Silver	Mexico	30.3	United States	23.0
Sulfur ††	United States	34.4	Japan	14.8
Tin ore *	British Malaya	27.1	Neth. E. Indies	17.1
Tungsten ore ‡‡	China	37.4	Burma	17.7
Vanadium ore *	Peru	30.9	United States	27.4
Zinc ore *	United States	25.1	Australia	12.0

* Percentage based upon metal content of ore production.
† Austria included with Germany in 1938.
‡ United States normally ranks first.
§ Percentage lower than normal because of depression in business.
‖ Mica: blocks, splittings, and sheets.
¶ Data based upon tricalcium phosphate content.
** Data based upon potassium oxide content.
†† Sulfur: native and pyritic.
‡‡ Data based upon 60% tungstic oxide content.

Source: Magnesium data from *Minerals Yearbook, Review of 1940*, p. 708. Shale oil data from *Statistical Year-Book of the League of Nations, 1940/41*, p. 128. All other data adapted from Charles K. Leith, James W. Furness, and Cleona Lewis, *World Minerals and World Peace,* The Brookings Institution, Washington, 1943, p. 38.

American mines are now confronted with production costs that compare unfavorably with the costs of leading producers abroad, and, in any case, the tariff enables American producers to charge a higher price on all copper mined and sold in this country. While various attempts have been made to stabilize and fix prices and to reduce competition among the leading producing countries, none of these schemes has achieved more than temporary success.[41]

Predominance of Blister and Refined Copper. At the present time all of the large producing nations are well equipped with facilities for processing copper, and a preponderant share of the world's international trade consists of blister and refined copper.[42] Only in the case of minor producing countries are exports dominated by ore, concentrates, and matte. Thus, in 1938 the entire exports of Norway, Cyprus, and Spain consisted of ore, concentrates, or matte destined for the smelters and refineries of Germany, similar shipments being made from Newfoundland, Cuba, Bolivia, and Australia to the United States. Among the major producers in 1938, only the Belgian Congo and Canada exported substantial amounts of copper in crude form, yet such shipments comprised a minor portion of their total copper exports.[43] Only 4% of Chilean copper was shipped without smelting, and almost the entire copper export trade of the United States and Northern Rhodesia consisted of blister and refined copper. As a consequence of this well-developed tendency to ship the more valuable, less bulky processed product, the transportation radius of copper has been increased, and the copper producing areas have gained employment from the initial stages of manufacture.

[41] See Charles K. Leith, James W. Furness, and Cleona Lewis, *op. cit.*, pp. 107-110.

[42] In 1938 the estimated copper content of all international trade in copper ore, concentrates, matte, and burnt cupreous pyrites amounted to 202,000 metric tons, whereas the total exports of "smelter copper (including refined)" amounted to 1,380,000 metric tons.—*Ibid.*, p. 240.

[43] In 1938 the metallic content of copper matte exported from the Belgian Congo amounted to 50,200 metric tons, as compared with exports of 78,700 metric tons of blister and refined copper. The copper content of Canadian exports of ore, concentrates, and matte amounted to 49,800 metric tons, in contrast with exports of 170,800 metric tons of blister and refined copper.—*Ibid.*

. . . 8

Aluminum, Tin, Nickel, and Other Mineral Industries

1. Aluminum

The Decline in Price and Increase in Demand. In contrast with copper, which was discovered and used by prehistoric man, the production and use of aluminum is entirely the result of modern scientific research. Aluminum was not discovered until 1825, when the Danish scientist, Hans Christian Oersted, succeeded in isolating a few tiny globules of the metal from its ore. Twenty years later a German experimenter, Friedrich Wöhler, was able to extract enough metal to analyze its physical properties and found that aluminum is exceptionally light. However, aluminum continued to remain a laboratory curiosity, worth more than $500 a pound, until the French chemist, Henri Sainte-Claire Deville, developed a process in 1856 that permitted the production of about 2 tons a year at a cost of $17 a pound. Even at this reduced cost, aluminum was still a precious metal, its use being confined to the manufacture of jewelry and novelties. The problem of producing low-cost aluminum continued to baffle the scientific world until February 23, 1886, when Charles Martin Hall, a twenty-two-year-old graduate of Oberlin College, turned to electricity as the best means of reducing aluminum oxide to metallic aluminum.[1]

In 1888 the Pittsburgh Reduction Co., which later became the Aluminum Company of America, began commercial production with the Hall process, aluminum selling for $5 a pound. With further technological improvements, the development of large-scale production, and a steady reduction in the cost of electric power, the price of ingot aluminum continued slowly downward, decreasing from 59¢ a pound in 1895 to 20¢ in 1913, and to 15¢ in 1941.

As the price declined and as the useful properties of the new metal came to be more widely appreciated, the demand increased, and the world's production of aluminum expanded from 1,800 metric tons in 1895 to 64,000 tons in 1913, and to more than 1,150,000 tons in 1941. Germany and the United States each produced about one-fourth of the total output in 1941 and were followed in importance by Canada, Japan, Russia, and France.

[1] Hall dissolved the oxide in a crucible filled with molten cryolite and passed an electric current through the solution, aluminum settling to the bottom. Only two months later a young Frenchman, Paul L. T. Héroult, made the same discovery independently, and the electrolytic reduction process is often called the Hall-Héroult process.

Qualities and Uses of Aluminum. The outstanding quality of aluminum is its light weight, as a cubic foot of aluminum weighs only 167 pounds, as compared with 556 pounds for copper and 487 pounds for ordinary steel. Aluminum is soft and can be easily shaped by rolling, forging, casting, extrusion, or drawing, and it is easily welded.[2] Furthermore, the metal is a good conductor of heat, is only slightly inferior to copper as a conductor of electricity, and unites easily with copper and other metals in the formation of alloys. Because of its affinity for oxygen, it is used to separate other metals from their oxides and thereby has cheapened the production of rarer metals such as chromium, manganese, tungsten, and vanadium. About half a pound of aluminum, chiefly remelted scrap, is used to deoxidize and purify each ton of molten steel produced in this country.

During the early growth of the industry, most of the output was devoted to the manufacture of cooking utensils, but the expansion of automobile and airplane manufacture during and after World War I created important new markets for the lightweight metal, and the transportation industry has become the leading consumer (see Table 17). The average automobile of 1939 contained about 12 pounds of aluminum, and the metal was being used in the manufacture of coaches for streamlined trains. It is estimated that from 54% to 80% of the weight of an airplane consists of aluminum, and the giant four-motor bombers built during World War II contained as much as 17½ tons of the metal. Because of the saving

TABLE 17

PERCENTAGE OF INDUSTRIAL USES OF PRIMARY ALUMINUM IN THE UNITED STATES

	1933–38 average	*1939*	*1941*
Transportation (air, land, water)	29	40	63
Machinery and electrical appliances	15	9	6
Cooking utensils	14	6	1
Electrical conductor	10	5	0
Building construction	8	5	3
Food and beverage	6	2	0
Chemical	5	5	5
Metallurgical	5	4	2
Foundry and metal working	4	23	19
Miscellaneous	4	1	1
	100%	100%	100%

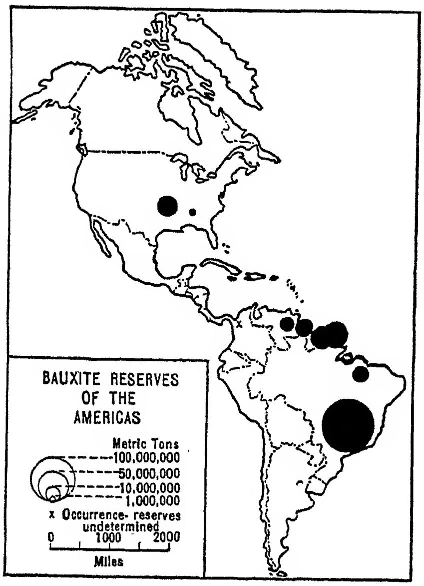
in weight, steel-cored aluminum cables have virtually displaced the use of copper in high-tension power lines,[3] and aluminum structural shapes have helped to reduce the amount of excavation and foundation work in the construction of skyscrapers. As America prepared for war, the manufacture of aluminum foil, paint, collapsible tubes, bottle caps, and other non-essential articles was curtailed and eventually eliminated, and an in-

[2] As a result of improved die castings, parts were easily made for such products as washing machines, vacuum cleaners, radios, and electrical appliances. Furniture and structural shapes for aircraft could be made following the development of extrusion, a process that consists of forcing hot aluminum ingots through a die very much as toothpaste is squeezed from a tube.—Evan B. Alderfer and Herman E. Michl, *Economics of American Industry,* McGraw-Hill Book Co., Inc., New York, 1942, p. 93.

[3] The light weight of aluminum cables permits the supporting towers to be spaced farther apart, thereby lowering the cost of constructing and maintaining power lines. In 1939 about 850,000 miles of steel-reinforced aluminum cables were in use in the United States.—U. S. Dept. of Interior, *Minerals Yearbook, 1940—Review of 1939,* Washington, 1940, p. 649.

creasing portion was devoted to airplanes. The tremendous demands of war caused the production of aluminum in the United States to increase from 130,000 metric tons in 1938 to over 1,000,000 tons in 1943.

The Mining of Bauxite. In spite of the fact that aluminum is the most



In America bauxite proves to be a low latitude resource, usually the result of extensive leaching in lands of very heavy rains.

abundant metal to be found in the earth's crust,[4] existing in great quantities in common clay, bauxite thus far has proved to be the only ore from which aluminum can be produced economically on a large scale. The aluminum oxide content of high-grade bauxite ranges from about 50% to 60%, in contrast with clay, alunite, and other materials that contain only 20% to 35%. Of the world's output of 6,400,000 metric tons of bauxite in 1941, about two-thirds was mined in Dutch Guiana (Surinam), British Guiana, Hungary, and the United States, most of the remainder being produced in France, Italy, Yugoslavia, and Russia.[5] Over 90% of the American production occurs in Pulaski and Saline counties, Arkansas, but two-thirds of our bauxite supply is usually imported from British and Dutch Guiana.

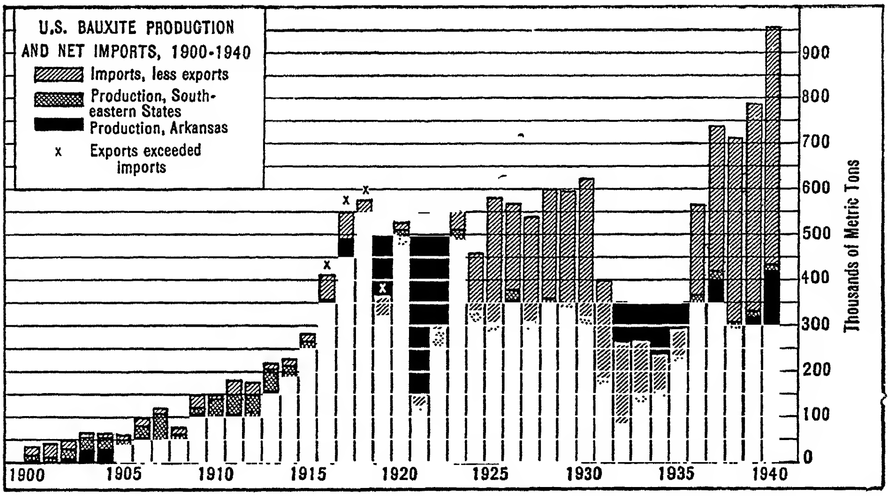
The Production of Alumina and Aluminum. After bauxite is mined, it is generally crushed, washed, dried in rotary kilns, and screened prior to shipment. The first step in the manufacture of aluminum involves purification and concentration of the ore, which is usually accomplished by the Bayer process. The bauxite is treated with caustic soda; the iron, silica, and other impurities are removed from the solution; and the aluminum hydrate is then precipitated and dried. The concentrated product is aluminum oxide, a whitish powder known as alumina.[6] The second step involves the reduction of alumina to aluminum, which is achieved by electrolysis,[7] the metal obtained by this

[4] It is estimated that over 8% of the outer ten-mile shell of the earth consists of aluminum and that 5% is iron.—National Resources Committee, *Technological Trends and National Policy*, Washington, June, 1937, p. 352.

[5] In 1938 the world's output of bauxite amounted to 3,800,000 metric tons, about 70% of which was mined in France, Hungary, British Guiana, and Dutch Guiana.

[6] To produce 1 ton of alumina, one plant uses 2 tons of high-grade bauxite, 2 tons of coal, 2 tons of caustic soda, and 2 tons of pure limestone. During World War II, when poorer bauxite had to be used, 3 tons of bauxite were needed.

[7] Manufacture of aluminum from alumina is performed in a series of reduction cells, each producing about 250 pounds of aluminum per day. After cryolite has been dissolved by an electric current, alumina is added, the current breaking down the alumina into aluminum and oxygen. The oxygen combines with the carbon anodes, and the resulting carbon dioxide and carbon monoxide escape through the crust at the top, where the carbon monoxide burns. The molten aluminum is



This graph shows that aluminum belongs in the class with iron and copper as industrial barometers; also our dependence upon one small area in the United States and especially upon imports, unless and until we discover an inexpensive way of getting aluminum out of common clay, of which there is so much.

process being ready for final fabrication. To produce 1 pound of metal by electrolysis requires 2 pounds of aluminum oxide, 0.8 pound of carbon anodes, 0.1 pound of cryolite, 0.1 pound of fluorspar, and 12 kilowatt hours of electricity, or enough electricity to keep a 40-watt lamp burning continuously for 12½ days.[8] Indeed, it is estimated that in 1938 the aluminum industry of this country consumed enough electricity in one day to supply a city of 17,000 homes for one year.[9]

Location Factors. Since bauxite is a cheap and bulky commodity, weighing two or three times as much as alumina, it cannot stand the expense of long rail hauls. Hence, concentrating plants that produce alumina are located relatively near the bauxite supply or where water transportation is available. Thus, bauxite is shipped cheaply by water from British and Dutch Guiana directly to the Mobile, Ala., plant of the Aluminum Company of America. The company's plant at East St. Louis, Ill., obtains bauxite by rail from Arkansas and Guiana bauxite through the port of New Orleans, where it is transferred to barges that carry the ore up the Mississippi River. These two plants produced all of the alumina in this country prior to June, 1941, but since then government-financed plants, utilizing lower grades of bauxite, have been established by the Reynolds Metals Co. at Listerhill, Ala., and by the Aluminum Company of America at Baton Rouge, La.,

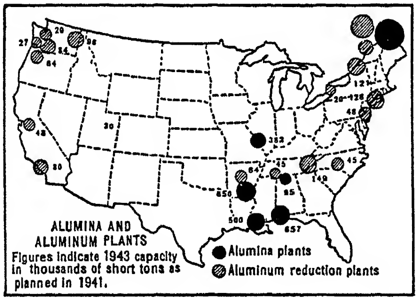
deposited at the bottom of the cells, and about every two days it is run into a mixing ladle from which it is cast into pigs.

[8] *Cf.* Evan B. Alderfer and Herman E. Michl, *op. cit.*, p. 96, and Harry N. Holmes, *Strategic Materials and National Strength*, The Macmillan Co., New York, 1942, p. 30. Cryolite is a sodium-aluminum-fluoride mineral, and the only known deposit is in Greenland. However, cryolite can be synthesized from calcium fluoride (fluorspar), soda ash, and sulfuric acid.

[9] Evan B. Alderfer and Herman E. Michl, *op. cit.*, p. 97.

and at Hurricane Creek, Ark. In Europe the movement of bauxite is facilitated by short rail hauls and by widespread use of the inland waterways.

Since the reduction of alumina to aluminum requires huge amounts of cheap electric power,[10] reduction plants are located in proximity to water-power sites. Among the important reduction



This map shows that there is little relation between the source of the ore and the place of its reduction. The influence of water power is noticeable. A large part of this capacity was plants financed by the United States Government as a war measure—World War II.

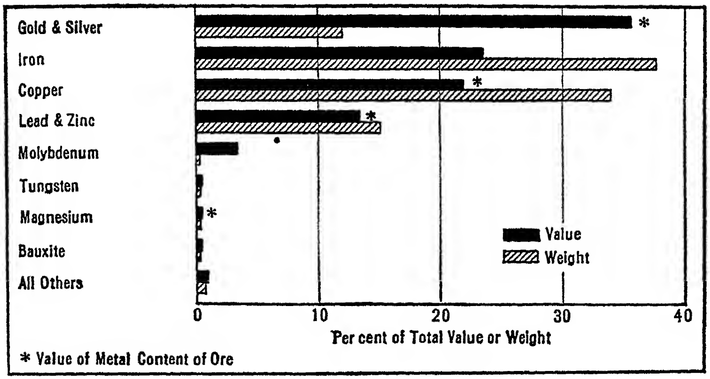
plants in this country are those at Niagara Falls, N. Y.; at Massena, N. Y., along the St. Lawrence River; at Vancouver and Longview, Wash., along the Columbia River;[11] at Alcoa, Tenn., and Listerhill, Ala., where power is derived from the Tennessee River system; and at Badin, N. C., which uses power obtained from the Yadkin River. In Canada an electrolytic reduction works operates at Shawinigan Falls, Que., while another large plant at Arvida on the Saguenay River obtains its power from dams not far upstream and manufactures alumina and aluminum from Guiana bauxite that is delivered alongside the plant by ocean vessels. Most of the companies working in Europe are located in the mountainous districts of Savoy, France (western Alps), of Switzerland, of Germany, of Italy, and of Norway. In Russia alumina produced from domestic bauxite is reduced to aluminum at Kamensk in the southern Urals, where the mountain streams have been harnessed for their power, and prior to the war two large plants operated near the famous Dnieper Dam, which was partially destroyed by the Russians at the time of the German invasion and later by the Germans at the time of their hurried departure.[12]

The Dominance of One Company. In spite of the fact that technological improvements and large-scale production methods have brought about a remarkable reduction in the market price of aluminum, its production is still very costly. For example, the Aluminum Company of America has invested hundreds of millions of dollars in bauxite mines, ocean vessels, water-power sites, concentration and reduction plants, and

10 Aluminum and magnesium are hogs for power, as the number of kilowatt hours used per pound in the production and refining of the following metals indicates: aluminum production—10 to 12, magnesium production—8, copper production—1.2, copper refining—0.06 to 0.10, steel scrap melting—0.35, tin recovery from scrap plate—0.085, and nickel refining—1.1.—National Resources Committee, *op. cit.*, p. 352.

11 According to one account, five reduction plants, using alumina from Mobile and power from Bonneville and Grand Coulee dams, produced 30% of all pig aluminum in the United States in 1943.—"Aluminum," *Time*, December 13, 1943, p. 84. See also James E. Collier, "The Aluminum Industry of the Western Hemisphere," *Econ. Geog.*, vol. 20, October, 1944, pp. 229-257.

12 Large bauxite deposits are worked at Kabakovsk (Nadezhdinsk) in the northern Urals and near Kamensk in the southern Urals. Low-grade ore is mined at Tikhvin, and aluminum is produced at Volkhov east of Leningrad. Huge nepheline deposits are worked for aluminum on the Kola Peninsula, aluminum being produced near Kandalaksha.—George B. Cressey, *Asia's Lands and Peoples*, McGraw-Hill Book Co., Inc., New York, 1944, p. 294.



Percentage distribution of value and weight—metallic ores produced in the United States, 1939.

metal derived from scrap.[15] Both before and after our entry into the war, the tremendous demands of the aircraft industry for aluminum and the growing need of bauxite for the manufacture of chemicals and abrasives caused a terrific drain upon our domestic bauxite reserves. Hence, strenuous efforts were made to collect and use aluminum scrap, to utilize lower grades of bauxite, and to find bauxite substitutes.[16] The Aluminum Company of America perfected and installed in its alumina plants a "red-mud reclamation" process which not only permitted the recovery of alumina formerly wasted in the residue resulting from the Bayer concentration process but also made possible the use of low-grade, high-silica bauxites. Another corporation, Kalunite, Inc., established a plant with an annual capacity of 30,000 tons, at Salt Lake City, to recover aluminum and potash from alunite mined at Marysvale, Utah, the alumina being shipped to reduction works at Tacoma, Wash., but the alunite deposits are apparently too small to yield an important supply of alumina.[17] In December, 1943, the War Production Board approved the construction of a $4,000,000 alumina-from-clay plant at Salem, Ore., to be operated by the Columbia Metals Corp., but unfortunately the great expense of removing silica and iron from clay thus far has precluded any important use of this exceedingly common raw material in the aluminum industry.

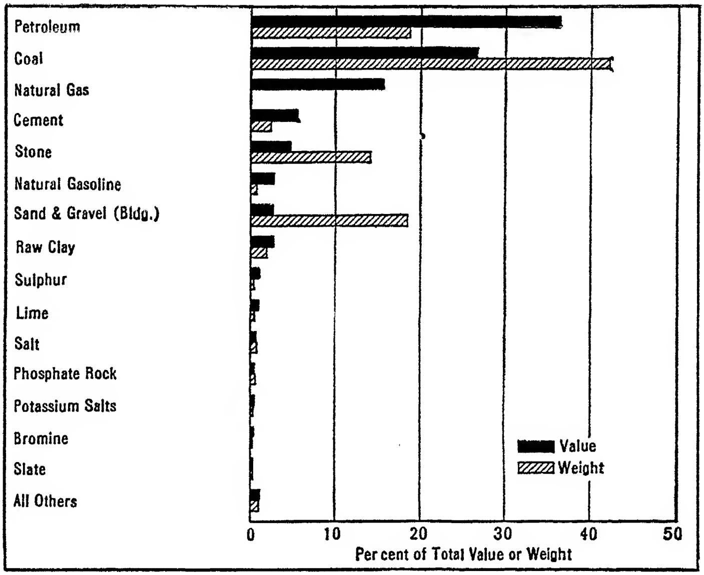
2. *Magnesium*

The Rise of Magnesium Production in Germany. Magnesium, like aluminum, is a newcomer in the metallurgical world, it is distinctly a product of scientific research, and its outstanding

[15] Only in 1934, a year of business depression, did secondary metal exceed virgin aluminum in output. Of 106,900 tons of secondary aluminum produced in 1941, about 60% was derived from new scrap, the remainder being recovered from old scrap.

[16] Late in 1943 it was said that our domestic bauxite reserves will be exhausted in 3 to 5 years and that we must develop sources from alunite and clay, if we desire self-sufficiency.—See "Aluminum: Have or Have Not?," *Fortune*, vol. 28. December, 1943, pp. 137-139 ff. Let it not be forgotten that "self-sufficiency" is unnecessary in a well-ordered, peaceful world!

[17] Proven reserves of alunite, with an alumina content of 20% or more, in this country amount to only 12,000,000 tons, but Kalunite, Inc., hopes to apply its process to clays and the lowest grades of bauxite.—*Ibid.*, p. 258.



Percentage distribution of value and weight—non-metallic minerals produced in United States, 1939.

quality is its lightness, for it weighs only two-thirds as much as aluminum and one-fifth as much as copper. In 1852 a German scientist, Robert Bunsen, derived pure magnesium by the electrolysis of fused magnesium chloride, and German chemists, eager to make full use of the great potash deposits at Stassfurt, found that they could use carnallite, a hydrous chloride of magnesium and potassium that is obtained cheaply as a by-product of potash production. In 1886 the first electrolytic magnesium plant, using carnallite as a raw material, began commercial production at Hemilingen near Bremen, and ten years later a larger plant was established at Bitterfeld. It was found that pure magnesium in the molten state ignites and burns very easily, that the pure metal has little strength and is practically worthless as a structural raw material, but that magnesium alloyed with other metals has great strength and durability. The Germans learned how to alloy magnesium with aluminum, zinc, and other metals, they developed the precise techniques needed in production and fabrication, and in time they came to make extensive use of the new metal in the manufacture of airplanes, automobiles, electrical equipment, and many types of machinery. Through control of patents German firms dominated the magnesium industry prior to World War I, and throughout the nineteen-twenties and 'thirties they turned out well over half of the world's magnesium.

Production in the United States. While Germany continues to obtain most of its magnesium as a by-product of the potash industry, elsewhere it is now derived from such abundant sources as dolomite, magnesite, the brines of salt wells, and sea water. Pro-

duction in the United States did not begin until the blockade of Germany during World War I shut off imports, at which time magnesium was sorely needed as a deoxidizer of nickel and in the manufacture of tracer bullets, flares, flashlight powders, and photographic materials. During the war magnesium sold for more than $5 a pound, but by 1928 the price had dropped to 55¢, and of the various firms that had engaged in wartime production only the Dow Chemical Co. remained in operation.[18] This firm had long been producing bromine and other chemicals from the heavy brines that lie in strata 1,500 to 5,000 feet beneath the surface of the earth at Midland, Mich. One of the salts obtained from crystallization of the brine is magnesium chloride, which is dried and broken down by electrolytic reduction cells into magnesium metal and a mixture of chlorine and hydrochloric acid. In spite of the fact that American manufacturers were slow to adopt magnesium for structural uses, Dow continued to spend vast sums on research[19] and to expand its output, with the result that by 1938 the price of magnesium had declined to 21.8¢ a pound as compared with 20¢ for aluminum. Of the world's output of 23,900 metric tons of magnesium in 1938, 14,100 tons were produced in Germany, 2,918 tons in the United States, and 2,200 tons in Great Britain.

One of the many miracles achieved by American industry during World War II was the expansion of our magnesium production to about 185,000 tons in 1943, or about four times the output of Germany.[20] During 1940-42 the government financed the construction of 14 new magnesium plants, employing 4 different processes with various modifications,[21] and while production costs among these plants ranged from several dollars a pound to as low as 13¢, the government set the price at 20½¢ and for a time absorbed all losses. Some of the plants encountered managerial and production difficulties, as was the case of the largest plant in the country at Las Vegas, Nev., that was eventually turned over to the Anaconda Copper Mining Co., which soon brought the plant's output up to its annual capacity of 56,000 tons. This industrial giant in the desert used magnesite as raw material and obtained its electric power from Boulder Dam. The largest plants to use dolomite as raw material were established at Lake Charles, La., Spokane, Wash., River Rouge, Mich., and Painesville, Ohio. Near Ludington, Mich., at a depth of 2,800 feet, the Dow Chemical Co. developed a new brine field, yielding brine three times richer in magnesium chloride than that obtained in the older Midland area, the salt being shipped to a plant at Marysville, Mich., to be enriched with dolomite and reduced to metal.

[18] For an account of the development of this company, see *Dow and Magnesium,* The Dow Chemical Co., Midland, Mich., 1944.

[19] For each dollar paid as dividends to stockholders, the Dow Chemical Co. spends 65¢ to 70¢ on research, one of the highest ratios in American industry.—"Dow Goes Down to the Sea," *Fortune,* vol. 26, December, 1942, p. 112.

[20] See "Magnesium by the Ton," *Fortune,* vol. 29, March, 1944, pp. 157-159 ff.

[21] The four basic processes were (1) electrolytic reduction of magnesium chloride from brine and sea water, accounting for 34% of the nation's total planned capacity, (2) electrolytic reduction of magnesium chloride from magnesite, dolomite, and other ores, accounting for 38%, (3) thermal reduction of dolomite with ferrosilicon, 24%, and (4) carbothermic reduction of magnesium oxide, 4%.—For a detailed description of these processes, see *ibid.,* pp. 181 ff.

Magnesium from Sea Water. A unique and one of the most successful of all wartime developments occurred at Freeport and Velasco, Tex., where the Dow Chemical Co. established huge plants for the recovery of magnesium from sea water. Since only 4 out of 1,000 parts of sea water consist of magnesium chloride, crystallization was impractical. Along the seashore were built huge settling tanks into which millions of gallons of sea water are poured and mixed with tons of crushed, calcined oyster shells, the magnesium chloride of the water uniting with calcium hydroxide of the shells to form pools of chalky magnesium hydroxide, or simple milk of magnesia, which in turn is thickened, cleansed, and treated with hydrochloric acid to yield magnesium chloride. After drying, the chloride is fed into electrolytic cells, where it is reduced to metallic magnesium. Although the Freeport and Velasco plants consume large amounts of electric power, averaging 10 to 14 kilowatt hours per pound of metal, they are lucky in having cheap natural gas as fuel, and the process proved so efficient that these plants produced magnesium at the extremely low cost of 13¢ to 15¢ a pound. Hence, man now has available an inexhaustible source of magnesium.

Wartime and Peacetime Uses. During the war year of 1943 about 40% of the American output of magnesium was devoted to the manufacture of incendiaries,[22] magnesium bomb casings having the advantage of being lighter than those made of steel and burning speedily when the bomb goes into action. Approximately 30% of the output was used to make fabricated parts for aircraft, averaging ½ ton of metal per plane, the substitution of magnesium for aluminum or steel enabling a plane to carry more men, bombs, guns, or gasoline. In times of peace, magnesium alloys will play an increasing role in the reduction of the weight of aircraft, railway cars, automobiles, bicycles, baby carriages, home and office furniture, tools, machines, and gadgets galore. While American industry still has much to learn about the final fabrication of the metal, the postwar era should witness some interesting competition between magnesium, aluminum, special quality steels, and plastics.

3. *Tin*

The Uses and Production of Tin. Despite the popular impression that it is hard and tough, tin is really the softest of our commonly used metals. Because of its softness and malleability, tin can be rolled into sheets only two ten-thousandths of an inch in thickness. Tinfoil is nothing but pure tin rolled out into thin sheets, while the "tin" can is a steel can with a thin coating of tin. The metal is valuable chiefly because it is airtight and does not rust, therefore making it a good protective covering for sheet iron and steel in manufacturing so-called tin cans, tin roofing, and many other articles. In the canning of fruits, vegetables, and other products, the tin-coated can is invaluable because it excludes every bit of air, while air can get through the pores of thin steel. Since prehistoric times tin has been alloyed with copper to make bronze; it is fused with lead to make solder; and it is alloyed with copper and antimony in

22 "Magnesium," *Time,* March 20, 1944, p. 79.

the production of babbitt metal, commonly used in the manufacture of bearings.[23]

Luckily, new applications of science to industry have not increased the use of tin as rapidly as they have of copper, nickel, iron, and many other metals. Any greatly enlarged demand might have created an acute tin famine. Tin is generally considered to be a rare metal; the world's output, about one-twelfth that of copper, increased only 3½ times between 1880 and 1939[24]—and fear of scarcity, whether justified or not, tends to keep the price up. It is one of the metals of importance to industry in which the United States is almost entirely lacking. We are using in this country about half the tin mined in the world, the value of our tin imports in 1941 being $177,000,000. Alaska is the only part of the United States where any regular production of tin continues, and its output in 1941 was only 54 tons. The tin mines of Cornwall, England, are among the most conspicuous mines in history, as they were worked long before the Christian era, and seem to have been the basis of important trade between England and the Mediterranean countries in the time of the Phoenicians. At the present time these mines are doubtless producing as much as they did in ancient times, but their yield of 1,600 tons in 1941 was an inconsequential portion of the world's total output of 240,000 tons. The Malay Peninsula produces over 30% of the world's supply, and the nearby Dutch islands of Banka, Billiton, and Singkep produce about 21%. Bolivia contributes about 17% and the balance comes largely from Thailand (Siam), Nigeria, the Belgian Congo, China, and Burma.

The Tin Industry of British Malaya. The centuries-old Cornwall mines are more than 3,000 feet deep, but in the Malay Peninsula and adjacent Dutch islands are large areas of tin-bearing alluvial gravels in which many thousands of Chinese coolies have worked for years in a careless manner as the individual pan miner works for gold. Prior to 1892, when the first British company began operations, tin-mining in Malaya was almost entirely in the hands of the Chinese, and as late as 1920 about 64% of the Malayan output came from Chinese-owned mines.[25] These easily worked deposits have gradually declined in productivity, and the big corporation, with costly large-scale mining equipment, has eclipsed the small-scale enterprise of the Chinese, with the result that in 1939 about 69% of all Malayan tin came from mines owned by European interests. Most of the tin is mined in the states of Perak and Selangor, the Kinta district alone yielding 45% of the Malayan output. Huge dredges, equipped with buckets and pumps, are used to lift the tin-bearing gravels into the washing trays, and a centrifugal pump and six or eight men per shift can do as much work in twenty-four hours as do 500 Chinese

[23] In 1940, 40% of all tin consumed in the United States was used in the manufacture of tin plate (which has an average tin content of only 1½%), about 20% was used in solder, 15% in bronze and brass, and 7½% in babbitt metal. Tinfoil, collapsible tubes and pipes consumed a large proportion of the remainder.

[24] During this sixty-year period, there was a fivefold increase in the output of iron ore and lead, a sevenfold increase in zinc, a fourteenfold increase in copper, a two-hundred-and-twenty-two-fold increase in nickel, while between 1895 and 1939 aluminum increased 735 times.

[25] Kate L. Mitchell, *Industrialization of the Western Pacific,* Institute of Pacific Relations, New York, 1942, p. 182.

with hand methods. Some tin is mined on higher ground where open-pit methods can be used. Alluvial deposits are usually trivial in comparison to the lodes from which they were washed. Several lode mines are now being operated with considerable success in the Malay Peninsula, the Sungei Lembing mine in the state of Pahang being the largest tin-lode mine in the world, but lodes at present yield only 4% of the Malayan output.[26] As the alluvial deposits are worked out, mining will shift to the rich lodes or veins deep in solid rock, which will be more costly, but the era of shaft-mining should last long.

At Singapore and Penang are huge smelters and refineries, owned by two British firms, that smelt about 44% of the world's tin.[27] These firms monopolize smelting of Malayan tin, and about one-third of their business consists of treating ores and concentrates imported from Thailand, Burma, the Netherlands East Indies, and at times from other sources.

Other Deposits in Southeastern Asia. On the islands of Banka and Singkep the tin mines are owned and operated by the Dutch Government, which also has a controlling interest in the mines of Billiton. While Banka tin is smelted locally, the output of Billiton and Singkep is usually exported to smelters in Arnhem, Holland, and Singapore. In southern Thailand the major deposits are exploited by British and Australian companies which employ modern hydraulic methods, although numerous small holdings are worked in a primitive manner by the Chinese. British firms also dominate production in Burma, where a large part of the output is derived from tin-tungsten ores mined in the Mawchi and Tavoy districts.

In China mining occurs in the provinces of Yunnan, Kwangsi, and Hunan, and on the island of Hainan, but the great bulk of the output comes from the Kochiu district of southern Yunnan, where about 100 mines employ 80,000 to 100,000 workmen. While a modern smelter has been operated by the government at Kochiu since 1932, most of the concentrates and ore are normally shipped by rail to be smelted at the port of Haiphong in French Indo-China or to be re-exported for treatment at Hongkong.[28] In the aggregate, these tin-mining districts of southeastern Asia usually produce over two-thirds of the world's tin.[29]

The Bolivian Tin Industry. In Bolivia, which ranks after British Malaya and the Netherlands East Indies in tin production, rich tin ores occur in lodes that are scattered throughout the Cordillera Real, or eastern range of the Andes. While tin is mined in about 25 districts, about a half of the Bolivian output is derived from mines that cluster about Cerro de Llallagua, a mountain south of Oruro, and much of the remainder is obtained from the Caracoles district between La Paz and Cochabamba. These mining districts lie in a mountain and plateau region at an elevation of about 14,000 to 18,000 feet,

[26] *Ibid.*

[27] *Ibid.*, p. 183.

[28] About 1,500 tons of tin are mined each year in French Indo-China, chiefly in Laos and northern Tonkin.

[29] The chief tin mining district of Australia is at Mount Bischoff, Tasmania, worked by open-pit methods, and in New South Wales are smaller deposits that are worked by dredges. Most of the nation's output of about 3,500 tons is consumed at home.

several hundred miles from the sea. The miners are unskilled Indians, lowly peons who receive a lowly wage of 20¢ to 30¢ a day. No tin is smelted in Bolivia, for this cool and dry plateau has no coal, no oil, and no wood; imported coal costs about $40 a ton; and *taquia,* or dried llama dung, and *yareta,* a woody resinous fiber, must serve as fuel.

Before shipment, the ores are concentrated so that they consist of about 45% to 55% pure tin, but many of the mines have difficult access to railroads, and tin ores and concentrates are often carried on the backs of sure-footed mules, burros, and llamas down tortuous mountain trails. Railway rates are very high, and it has been estimated that freight charges from the concentrating mill to the Peruvian seaport of Mollendo are 6½ times the cost of mining and concentrating 1 ton of tin and are 6 times the ocean freight rate from Peru to Great Britain.[30] Tin means much to Bolivia,[31] for the mines employ thousands of workmen, and tin accounts for about 70% of the total value of the nation's exports.

Tin Mining in Africa. In Nigeria tin is obtained from the alluvial deposits of the Bauchi Plateau; when the mines were first opened (1911), Nigerian tin ore was carried on the backs of natives 190 miles to the navigable waters of the Benue, the eastern branch of the Niger, making a freight cost of $60 per ton to the coast. Today, however, tin concentrates are shipped by rail from the Bauchi Plateau to Lagos and Port Harcourt on the Gulf of Guinea, and thence to Great Britain for smelting. In the Belgian Congo, tin is mined in the Katanga, Maniema, and Ruanda-Uruni districts, it is derived from both alluvial and lode deposits, and most of the output is now smelted locally prior to exportation. A direct rail route now connects the mining area with the Atlantic port of Benguela, and a good rail-and-water route extends northwestward to the port of Matadi near the mouth of the Congo River.

As unknown portions of the earth are prospected more thoroughly, additional tin deposits should be discovered. Better processes and deep mining as practiced in Cornwall will enable the known deposits to yield an increasing output for many decades. Furthermore, much progress has been made in the recovery of tin from scrap, and in the United States about 20% to 25% of all tin consumed each year is secondary metal.

British Domination of the Tin Industry. While the mining of tin now occurs in widely separated areas, the British have long exercised an almost complete control over the tin industry. This has been accomplished by political and financial control of important sources of tin, by ownership of smelting facilities, and by levying an excessive export tax on any tin destined for smelters out-

[30] See Ray H. Whitbeck and Frank E. Williams, *Economic Geography of South America,* McGraw-Hill Book Co., Inc., New York, 1940, p. 159. As Bolivia has no seacoast, tin is exported through the Peruvian port of Mollendo and the Chilean port of Antofagasta.

[31] Tin also has meant much to Simón Patiño, who was born a poor *cholo,* or half-Indian, in Cochabamba and who now is the richest man in South America with a fortune variously estimated at $200,000,000 to $500,000,000. Patiño's tin mines now produce about half of all Bolivian tin; at one time or another he has controlled important banks, railroads, and the nation's alcohol monopoly; he has large investments in Nigerian and Malayan tin mines; he owns a huge smelter near Liverpool; and he holds an interest in the National Lead Co., one of the largest American consumers of tin.

side of the British Empire.[32] In 1903 the United States Steel Corporation, our largest manufacturer of tin plate, completed a smelter at Bayonne, N. J., but the plant was doomed to failure, because the Malay Protected States (now the Federated Malay States) levied a high export tax on all ore shipped to smelters outside of the Straits Settlements. Again, during World War I, the American Smelting & Refining Co. built a plant at Perth Amboy, N. J., and the National Lead Company and Harvey Williams, an English firm, constructed a plant at Jamaica Bay, Long Island, which operated successfully for a time. However, after the war was over, the smelting companies in England cut their price by more than one-half for treating Bolivian tin, which is difficult and costly to smelt unless it is mixed with simpler types, such as those produced in Nigeria and Malaya. Then, the British government levied a high export tax on Nigerian tin shipped outside the Empire. Hence, all shipments of Bolivian and Nigerian tin were effectively diverted to Great Britain, and the smelters in this country were forced to close down.

Finally, in 1931, when the price of tin was dropping to unusually low levels during the worldwide depression in business, the British government secured the cooperation of the Dutch, Belgian, and other governments of important tin producing countries to establish a cartel, known as the International Tin Committee, for the purpose of controlling production, exports, and prices. At the outbreak of World War II, 90% of the world's tin ore was produced by countries belonging to this cartel; about 67% of the world's total smelting capacity was located in British Malaya, Great Britain, Hongkong, and Australia, and 20% was in Holland and the Dutch East Indies. Under the pressure of wartime necessity, the United States Government in April, 1942, opened a 50,000-ton smelter at Texas City, Tex., using Bolivian and African tin, but, in view of past history, the postwar survival of this plant is a moot question.

4. Nickel

The Changing Demand. Although nickel has been mined and used in small quantities for more than 2,000 years, its rise as an important industrial metal has been comparatively recent.[33] As late as 1885 the world consumed only 750 tons of nickel, which was used chiefly in coins and nickel silver. Three-fifths of the output came from recently discovered deposits in New Caledonia, the remainder being obtained from lesser deposits in Norway and Germany and from one small mine in Lancaster County, Pennsylvania. In the eighteen-

[32] For a thorough discussion of monopolistic aspects of the tin industry, see William Y. Elliott and others, *op. cit.*, pp. 277-362, and Charles K. Leith, James W. Furness, and Cleona Lewis, *World Minerals and World Peace*, The Brookings Institution, Washington, 1943, pp. 122-126.

[33] It is believed that nickel ores were first smelted in the province of Yunnan, China, and that the coins of the Greek kingdom of Bactria in Turkestan of about 235 B.C. contained Yunnan nickel as an alloy. Chinese metallurgists alloyed copper, zinc, and nickel to make *paktong*, or "white copper," which for centuries was used in the manufacture of gongs and musical instruments. Not until 1823 did Brandes, a German scientist, discover the formula for making *paktong*, which in the western world came to be known as "nickel silver."—William Y. Elliott and others, *op. cit.*, pp. 112-113. Today nickel silver is used as a base for silverplated ware and in filled-gold jewelry, coins, and hardware.

nineties demand for the metal increased as nickel came to be used in galvanizing iron, in electroplating, and especially as a steel-making alloy in the manufacture of armor plate for battleships.[34] About this time the world's available supply was greatly enlarged by the perfection of a process in 1893 that permitted the recovery of nickel from the copper-nickel ores of the Sudbury district in Ontario.[35] It was very largely the demand for nickel steel in the production of armament that caused the world's nickel output to increase from 3,000 tons in 1890 to 35,000 tons in 1913, and to 52,000 tons in 1918. This demand almost vanished during the nineteen-twenties, when disarmament programs were in vogue, but the growth of the automobile, construction, and other industries created new markets for nickel and its alloys. Indeed, in 1929 about 90% of all nickel was used for commercial purposes, whereas in 1913 about 90% had been consumed in armament manufacture.[36] In the late nineteen-thirties, nickel again went to war.

A Great Alloy. Nickel is commonly used as a surface coating for bathroom fixtures and other familiar objects. It performs valuable service as a catalytic or chemical reagent, it is used in storage batteries and for a great variety of purposes, but the outstanding fact about the consumption of nickel is that more than four-fifths of the world's supply is employed in the manufacture of alloys.[37] In recent years many useful products have been derived from a combination of nickel with chromium, aluminum, zinc, manganese, silver, gold, and other metals.[38] However, the primary use of nickel as an alloy material is in conjunction with iron and copper, more than three-fourths of all nickel being alloyed with these two great industrial metals.

Nickel has great tensile strength, it resists corrosion and the action of most acids, it melts at 2,646° F., and its electrical conductivity is only 15% that of copper. These qualities are imparted to alloys by the metallurgist, a wizard in combinations and permutations, who is able to meet the diverse needs of industry by skillfully adjusting the proportion of nickel to be used in conjunction with other metals. Thus, nickel is extensively used in the manufacture of structural steel, a product that must have great tensile strength, the nickel content varying with the requirements of the finished products. Heat-resistant steels contain 7% to 35% nickel and are especially useful in making equipment for the ceramic, glass, metal, and oil refining industries and for use wherever high-temperature chemical processes are

[34] In 1891 the United States Navy made a test of nickel-steel plate, obtained from the armament works at Le Creusot, France, demonstrating its superiority over ordinary steel plate, and Congress appropriated $1,000,000 for the purchase of nickel. —*Ibid.*, p. 113.

[35] For a description of the Orford process that enabled the separation of nickel and copper in Sudbury ores, the Mond process which was developed and used in England, and the process of electrolytic refining, see *ibid.*, pp. 123-125, and U. S. Dept. of Interior, *Minerals Yearbook, 1935*, Washington, 1935, p. 577.

[36] William Y. Elliott and others, *op. cit.*, p. 116.

[37] It is estimated that 42% of all nickel is consumed as an alloy of iron and steel, 31% in the production of Monel metal, 7% for nickel plating, 6% as malleable nickel, 5% in nickel silver, 5% in heat-resistant and electrical alloys, and 4% in other uses.—U. S. Dept. of Interior, *op. cit.*, p. 578.

[38] For example, white gold used in jewelry has a nickel content of 15%; rose gold, 5% or 6%; and green gold, 1% or 2%. For a description of the composition and uses of the principal nickel alloys, see William Y. Elliott and others, *op. cit.*, pp. 183-186.

employed. In the manufacture of stainless steel, about 8% nickel and 18% chromium are alloyed with low-carbon steel, the resulting product being highly resistant to corrosion. Likewise, Monel metal, an alloy chiefly of nickel and copper with a nickel content of 68%, resists corrosion and the action of most acids; hence, it is commonly used in making marine shafts and propellers and many kinds of equipment for kitchens, canneries, hospitals, laundries, and chemical laboratories. If a heat and electrical resistant alloy is needed, as in the manufacture of heater and rheostat wire or in electric furnace heater elements, chromium and nickel are combined, the nickel content ranging as high as 85%. In prewar years, our ubiquitous five-cent piece contained 75% copper and only 25% nickel, although for years it has been popularly known as a "nickel." These few illustrations give some idea of the versatile service rendered by nickel as a component of alloys.

Concentration of Production. The outstanding fact about the production of nickel is the extreme concentration of mining in two areas. Of the world's total output of 115,500 tons in 1938, 83% was mined in the Sudbury district of Ontario, Canada, and 10% was mined on the French island of New Caledonia in the South Pacific, most of the remainder being produced in Russia, Norway, and Greece. The New Caledonian district began production in 1875, and in the early years ore of 10% to 12% nickel content was mined, but the average grade shipped has since fallen to about 5%. This island led the world in nickel production until 1903, when it was surpassed by the Sudbury district. Nickel ore in New Caledonia occurs in small, scattered, surface deposits that are not amenable to large-scale operations, nearly all of the mining and sorting of ore being performed by manual labor. Most of the output is smelted prior to exportation, and the nickel matte, averaging 77% in metallic content, is usually shipped to France, Belgium, and Germany for refining. One company, the Société Calédonickel, dominates the island's nickel industry, for its mines yield two-thirds of the total output, and the company purchases much of the nickel mined by independent producers.

In contrast with the New Caledonian deposits, those of the Sudbury district in Ontario are the largest in the world, they are worked by modern large-scale mining methods, and they have an important advantage of being near to the American market, which consumes about half of the world's annual output of nickel. Furthermore, Sudbury ores are especially profitable since they yield not only nickel but also important amounts of copper and platinum. The Sudbury Basin, which is only 36 miles long and 16 miles wide, is said to contain 207,000,000 tons of ore, averaging about 2.4% in nickel, and all but 3,000,000 tons of this great reserve is owned by the International Nickel Company of Canada, Ltd. While open-pit mines have been developed in recent years, more than four-fifths of all ore is obtained by shaft mining.

Domination of Industry by One Company. The nickel industry is dominated by the International Nickel Company, which in 1939 mined 82% of the world's

nickel.[39] In addition to its mines and concentrating mills, this company owns a smelter at Coniston and a smelter and refinery at Copper Cliff in the Sudbury district; electrolytic refineries at Port Colborne, Ont., and Clydach, Wales; a plant at Acton, England, for recovering precious metals from the slimy residue of the refining process; and fabricating plants at Huntington, W. Va., Bayonne, N. J., Birmingham, England, and Glasgow, Scotland. It also has acquired control of nickel deposits near Petsamo, Finland, and in New Caledonia. The company has been able to maintain a fairly reasonable and stable price throughout years of both prosperity and depression, and thus far it has encountered little, if any, consumer resentment. It produces 10 times as much nickel as its only Canadian competitor, the Falconbridge Nickel Mines, Ltd., which operates mines and smelters in the Sudbury district and which ships matte to its electrolytic refinery at Kristiansand, Norway, where Norwegian nickel is also treated. Neither this firm nor the French company in New Caledonia offers any serious competition to the International Nickel Company. From the viewpoint of applied geography, there is really only one area and one business enterprise of significance in the nickel industry.

The United States is as poor in nickel as it is in tin. In 1940 this country recovered only 5,150 tons of secondary metal from scrap, and it produced only 619 tons of primary nickel, which was entirely a by-product of copper refining. For our nickel supply, we are dependent upon our great and good neighbor to the north.

5. *Lead*

The Antiquity of Lead. Man's first use of lead lies in the unknown prehistoric past, but it is certain that the ancients made common use of the metal. Lead is mentioned several times in the Old Testament,[40] and the silver-lead deposits at Laurium in Attica, owned by the Athenian state and worked from the sixth to the fourth centuries B.C., are said to have yielded 270,000,000 ounces of silver and 2,000,000 tons of lead.[41] In Roman times the imperial water-bureau not only provided the great aqueducts of Rome but also laid down lead pipes for the distribution of water to the imperial palaces, to public baths and gardens, and to a large number of public fountains whence the poor carried their water.[42] In those days the plumber was a manufacturer of lead, slaves being employed as workers in the lead-making shops and in laying and repairing pipes. Indeed, the modern word, plumber, is derived from the Latin, *plumbum*, meaning lead, and the irate householder of today, when in urgent need of repairs, may think that the plumber is laden with the metal as he slowly returns to his shop to fetch his tools. A

[39] For a discussion of the monopolistic features of the nickel industry, see William Y. Elliott and others, *op. cit.*, pp. 109-209, and Charles K. Leith, James W. Furness, and Cleona Lewis, *op. cit.*, pp. 130-132.

[40] See *Exodus* 15:10, *Numbers* 31:22, *Job* 19:24, and *Ezekiel* 27:12.

[41] William Y. Elliott and others, *op. cit.*, p. 613.

[42] The wealthy citizen, desiring water in his home, had to purchase pipe and pay to have it laid from the public water main to his home, often involving considerable distances. In order to protect his ownership, he had his name stamped on each piece of pipe.—Tenney Frank, *An Economic History of Rome*, The Johns Hopkins Press, Baltimore, 1927, pp. 239-241.

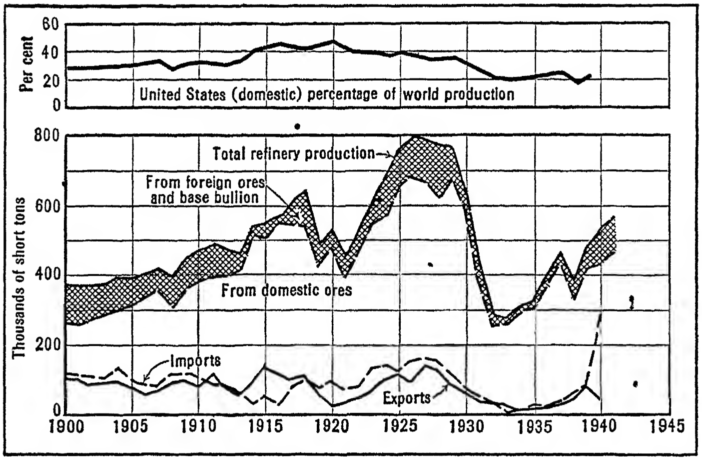
joke runs to the effect that a plumber one day went out with all the proper tools but he went to the wrong house.

Properties and Uses. Lead is a soft, heavy metal that melts at 621° F.; it is extremely malleable, unusually resistant to corrosion and the action of most acids, and easily alloyed with many metals; and it is a poor conductor of electricity. These qualities, together with its cheapness, have made it one of the most versatile of all metals. In recent years about 30% of all lead consumed in the United States has been devoted to the manufacture of storage batteries, and about 30% to 35% has been used as a covering for telephone, telegraph, and other electrical cables, in the construction industry, and in the production of white and red lead. While the use of white and red lead in the manufacture of paint has declined in recent years due to the increasing use of zinc, titanium, aluminum, and other pigments, the consumption of lead in storage batteries and cable coverings has increased. Other important uses include the manufacture of ammunition, lead foil, solder, bearings, and printers' type, and for calking ships. In times of war it is tetraethyl lead that makes possible the production of high-octane gasoline so vital to military aircraft; it is the storage battery that provides the spark in the power unit of every jeep, truck, tank, airplane, and submarine; and a war without lead would be more than a bulletless war.

Occurrence and Production. Lead is a gregarious sort of metal that is almost always found in the company of other metals. Most lead ores contain both silver and zinc, but in widely varying ratios, and are associated with other metals that may occur in minute or important quantities, such as copper, gold, antimony, molybdenum, vanadium, cadmium, bismuth, and arsenic. Such is the case of most of the world's famous lead deposits, including those of San Luis Potosí and Chihuahua in Mexico, Broken Hill and Mt. Isa in Australia, Kimberley in South Africa, Cerro de Pasco in Peru, the Bawdwin lodes in the Shan states of northern Burma, and many scattered deposits in Spain, Germany, Italy, and central Europe.

In certain areas lead and tin are found together, as in Cornwall, Bolivia, and Tasmania. In other areas lead ores contain silver but no zinc, as in the Linares-Carolina lodes of Spain which have been worked since before the Christian era. On the other hand, the Silesian ores of Poland and Germany, the Santander ores of Spain, and the Monteponi ores of Sardinia contain no silver. In the United States the leading lead producing district is in southeastern Missouri, the ores containing almost no silver or zinc, while those of the Rocky Mountain states are generally high in silver content and are often associated with copper, gold, and other metals. Therefore, it is clear that the prosperity of the lead-mining industry depends not only upon its own conditions of supply and demand but also upon those of silver, zinc, and other metals that are produced in conjunction with lead.

In response to the growing demand for lead and for the metals associated with it, the world's output of lead has increased from 408,000 short tons in 1880 to 1,269,000 tons in 1913, and to 1,919,000 tons in 1939. Although lead-



Trends in the lead industry, United States, 1900 to 1941. Imports include lead in ore, base bullion, pig bars and scrap. Exports include pig bars and scrap, lead exported in manufactures.

Upper graph shows heavy reduction in our share of world production since 1929. The depression of the 1930's seems to have hit lead very much as it did the other industrial metals.

bearing ores are mined in some 35 countries, the United States, Mexico, Australia, and Canada for some years together have produced well over three-fifths of the world's lead supply. Each of these leading nations is also a great producer of silver and zinc. As the ores of silver-lead-zinc deposits tend to occur in zones, many a mine has begun operations as a silver mine with lead as a by-product; as the shafts have deepened, it has become a lead mine with silver as an important by-product; and, at still greater depths, it has concluded its career as a zinc mine, yielding lead and a little silver as by-products.[43] In general, concentration and smelting of lead ores occurs within the mining districts, and the widespread adoption of the selective flotation process has lowered the cost of reducing complex ores and has brought about a more effective recovery of lead and the valuable metals that are mined with it.

In recent years scrap metal has become an increasingly important source of lead. While it is true that much lead is consumed in uses from which there is no recovery of metal, as in the manufacture of paint and ethyl gasoline, yet by far the major portion of all lead in this country goes into nondestructive uses and eventually returns to the smelter for reworking and reuse. More than half of the secondary lead produced in the United States each year is derived from discarded storage batteries, and much metal is obtained from old

[43] The chief lead-bearing ore is galena, or lead sulfide, and zonation results from its close association with zinc sulfides. As zinc ores are more soluble than lead ores, the zinc may be leached away, leaving almost pure lead carbonate above the water-table, but at greater depths the mixed lead and zinc sulfides remain. If the galena has a high silver content, secondary silver enrichment on the surface is a conspicuous feature. Hence, silver, lead, and zinc occur in rather well-defined top, middle, and lower zones.—See William Y. Elliott and others, *op. cit.*, p. 593.

cable coverings, pipes, printers' type, and bearing metal. The collection and smelting of scrap is now a well organized industry, and the methods of recovering the metal from scrap materials have been greatly improved. As a consequence, the production of secondary lead during the decade 1931-41, amounted to 60% to 87% of the primary output from domestic ores, in contrast with only 12% in 1914.

6. *Zinc*

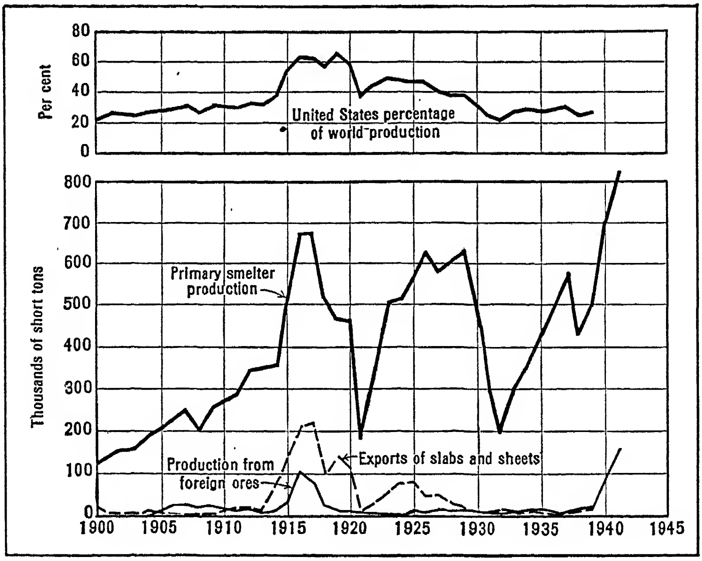
Man's Ally Against Corrosion. It seems to be Nature's intention to keep the metals, with few exceptions, in a state of corrosion. Man, with great stubbornness, is determined to prevent this from happening, yet in spite of his efforts, about 15% to 20% of all iron is eventually lost through rusting. In the battle against corrosion, one of man's greatest allies is zinc, which is used in galvanizing iron and steel. When a product is galvanized, it is simply cleansed in a bath of dilute acid and then immersed in molten zinc.[44] The zinc makes a smooth, protective coating which adheres tightly to the iron or steel base, since it forms an iron-zinc alloy at the surface contact. If the iron and zinc are exposed to the weather, so long as the two metals remain in contact, the zinc is oxidized first. Hence, zinc affords the protection of a Swiss Guard, for when the coating is broken, the zinc holds out as long as possible and perishes to the last atom before it lets oxygen at the iron.[45] The durability of a galvanized product, of course, depends upon the thickness of the zinc coating. Among the many products that are galvanized today are fences, posts, wire, cable, building roofs, culverts, tanks, pipes, pans, and pails. Between 35% and 45% of all zinc consumed in the United States each year is used in galvanizing iron and steel.

Secondary Uses. Second only to its prime function as a guardian against rust is the use of zinc as an alloy with copper in the manufacture of brass. This ancient function of zinc normally accounts for about one-fourth to one-third of the metal consumed in this country, brass being widely used in the construction, automobile, and electrical industries, in the manufacture of cartridges and hardware, and in the arts. Another important use of zinc is in die castings, including many automobile parts and a variety of household and office equipment. From rolled zinc are made such products as dry battery cans, boiler plates, and brake linings for automobiles, and a large tonnage of zinc goes into pigments for the manufacture of paint.

Distribution of Production. For decades the United States has been the

[44] In addition to this "hot-dip" method, zinc coatings are applied by electroplating, by "metalizing," and by "Sherhardizing." Electroplating is commonly used to coat wire and strip steel. Metalizing involves the use of a gun that sprays molten zinc on large objects that have already been erected, such as tanks and railway bridges. In the Sherhardizing process, small objects, such as nuts, bolts, and screws, are placed in a revolving container together with zinc dust, which are heated to about 800° F.—See John G. Glover and William B. Cornell (ed.), *The Development of American Industries*, Prentice-Hall, Inc., New York, 1941, p. 449.

[45] This is known as the "sacrificial action" of zinc. While zinc is negative toward iron, tin is positive. Hence, when a tin can or other plated object is scratched deeply, the iron beneath rusts more rapidly than if the tin were not there, for an electrolytic action is set up, and the iron suffers at the expense of the tin.—See *ibid.*, p. 448, and Edwin E. Slosson, *Creative Chemistry*, The Century Co., New York, 1930, p. 273.



Trends in the zinc industry in the United States, 1900 to 1941. Imports have been insignificant, except from the period 1937 to 1941, when the maximum of 37,000 tons was reached in one year. The wild fluctuations of zinc production show a close relationship to those of copper.

Upper graph apparently reflects the oft-stated limitation of our zinc resources.

world's leading producer and consumer of zinc, our mines in prewar years yielding about one-fourth of the world's supply. More than one-third of our zinc is mined in the tri-state district of eastern Oklahoma and Kansas and southwestern Missouri. While most of the mining was formerly done around Joplin, Mo., since 1915 the bulk of the output has come from the Oklahoma-Kansas section, centering around the town of Picher, Okla. The mines of this tri-state area are shallow, the deepest being about 400 feet, and the ores average only 4% in zinc content and only 0.8% in lead. Although its lead output has been steadily declining, this district remains the world's largest single producer of zinc. Second in output is the district around Franklin and Stirling, N. J., where unusually rich ores, averaging 19% in metallic content, have been worked commercially since 1848. Other important zinc mining areas are those of Coeur d'Alene, Idaho, which also is the nation's second largest producer of lead, St. Lawrence County, N. Y., Butte, Mont., and eastern Tennessee. As a whole, American ores average only 5% in zinc content, as compared with 13% for the rest of the world. Although the United States is by far the largest producer of ore and refined zinc, our imports and exports are normally very small. For many years the American zinc industry has received tariff protection, without which some of our zinc mining areas simply could not operate.

The Geological Survey reports in 1945 that only 35% of our known supply remains,

The principal foreign producers of zinc ore are Australia, Germany, Canada, and Mexico, the combined output of these countries amounting to about 40% of the world's supply. Germany consumes its entire output and imports both ore and refined metal. Most of the Australian output is exported to Great Britain and Belgium for smelting and refining, although a considerable export trade has developed in refined zinc, which is destined chiefly for British, Indian, and Japanese markets. Canada exports most of its output as refined metal to Great Britain, while Mexico ships ores and concentrates to Belgium and France. In some years ores and concentrates are imported into the United States to be smelted, refined, and then exported in the form of slab zinc, but this trade is generally small. Thus, the American zinc industry is distinctly domestic, while that of other countries is highly international in character. The world's output of zinc has increased from 257,000 short tons in 1880 to 1,112,000 tons in 1913, and to 1,802,000 tons in 1939.

Improvements in Recovery of Zinc. As a consequence of the widespread adoption of the selective flotation process, the recovery of zinc from ore increased from 30% to over 80%. Indeed, by 1925 it was evident that the world's available zinc resources had been at least doubled by this process, which also enables the effective recovery of silver, lead, copper, gold, and other metals frequently associated with zinc.[46] While the crushing and concentration of ore occurs within mining areas, the great bulk of the world's zinc is smelted and refined in or near great markets where fuel and skilled labor are available, particularly in eastern United States, Belgium, Germany, France, and Great Britain. In 1938 little Belgium was the world's leading importer of ore and the greatest exporter of refined zinc, its smelter output being second only to that of the United States.[47] However, the advent of electrolytic beneficiation has permitted the production of refined zinc in or near mining areas that have cheap electric power, as in Canada and our western states of Idaho and Montana.

While important reserves of other metals are being accumulated aboveground in the form of scrap, very little zinc is obtained from old scrap.[48] Much of the zinc used in the manufacture of brass remains and may be recovered, usually as brass, but there is no return whatever of zinc from such major uses as galvanized articles and the pigments used in paints. Practically the only zinc that is recovered is what originally has gone into rolled zinc, but unfortunately battery cans, brake linings, fruit jar tops, and many other articles made of rolled zinc are actually dissipated or seldom appear in the country's commercial scrap heaps. Far more than aluminum, copper, lead, and many other metals, zinc is a wasting asset.

[46] See William Y. Elliott and others, *op. cit.*, pp. 687-688.

[47] See Charles K. Leith, James W. Furness, and Cleona Lewis, *op. cit.*, pp. 82-84.

[48] In 1941 the smelter output of primary zinc from domestic ores in the United States amounted to 653,000 tons; about 203,000 tons of secondary zinc were recovered from new scrap, while only 81,000 tons were recovered from old scrap.—U. S. Dept. of Interior, *Minerals Yearbook, 1941*, Washington, 1943, pp. 144, 513.

7. Gold

Non-industrial Uses of Gold. On account of their remarkable malleability, durability, beauty, and comparative scarcity, gold and silver were highly prized for ornaments and coins even before the period of recorded history. After the discovery of America, the Spaniards' quest for gold led them to remote corners of the New World, and it is said by some historians that the great influx of gold and silver from the New World was the chief source of the power of the Spanish monarchy in the sixteenth century and of its later political and economic downfall. From 1493 to 1941, according to one estimate, the world's mines produced 1.4 billion fine ounces of gold and 17.5 billion fine ounces of silver.[49] The durability of gold and the human desire to keep it are well shown by the fact that gold mined before Caesar was born is a part of the great hoard that now lies in the vaults of the United States Government.[50] For many centuries the prime function of gold has been to serve as money, a medium of exchange and standard of value that proved to be universally acceptable.[51] Down through the ages untold quantities of the precious metal have been hoarded, especially by Oriental peoples. In normal times about one-fourth of the world's output of gold is used in jewelry, dentistry, chemistry, the arts, and for other purposes. Plainly gold is not one of the world's great industrial metals.

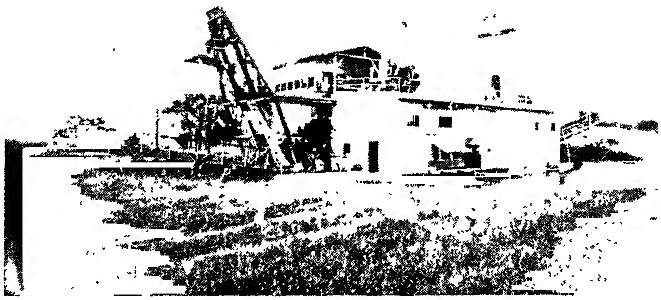
How Gold Is Obtained. Widely scattered in the earth's crust, gold is collected into veins of quartz in many kinds of rock. The destruction of exposed veins in the wearing down of mountains by streams has caused the transportation of gold along the courses of streams to great distances from the original veins. Sometimes the search for gold along these streams leads the prospector back to the vein or mother lode, from which the stream supply has been eroded. The miner's pan, not unlike a wash basin, suffices to extract the gold from the sand if there be water present in which to agitate the sand until the gold settles to the bottom so that the sand can be gradually separated from it.

Large banks of sand and gravel, containing very small quantities of gold, are worked by hydraulic mining, which consists of washing down the gravel banks by the force of a stream of water from a nozzle. The water carries the sand through long sluice boxes, with crevices in the bottom, in which the gold is caught, because, being the heaviest of the materials, it gradually settles to the bottom. This method has been used extensively in many parts of the world, especially in California, where streams have been so choked by debris as to fill up valuable channels in their lower courses and to cover rich agricul-

49 U. S. Treasury Dept., *Annual Report of the Director of the Mint, 1942,* Washington, 1943, pp. 103-104.

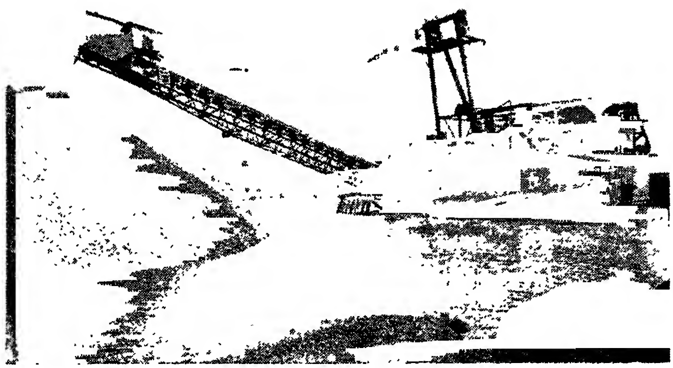
50 Of the world's monetary stocks of precious metals in 1941, the United States held 71% of the gold and 73% of the silver, as compared with only 21% of the gold and 17% of the silver in 1900.—U. S. Dept. of Interior, *op. cit.,* p. 56.

51 Gold has qualities that have long made it an ideal money commodity, namely, its durability, great value in small bulk, uniform quality, fusibility, cognizability, and general acceptability. Since gold is soft, it must be alloyed with harder metals to make coins that will wear. Since the abandonment of the gold standard in the early 1930's we have come to live in an era of "managed currency," yet many authorities believe that gold is the best medium of exchange that the world has ever known.



A

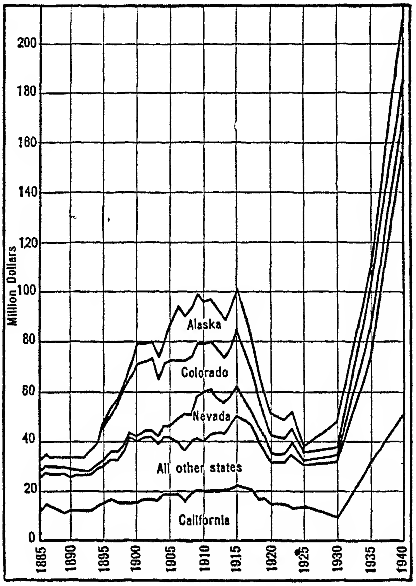
This picture and the next might be called "Before and After Taking," and it's bad medicine. This one shows a dredge, front view, floating in a pond of its own making, scooping up the beautiful meadow that makes up the foreground. Ten, 15, or 20 feet or more of the meadow, all the alluvial material that they can possibly get, is scooped up, run through the sluice boxes and thrown out behind the dredge, leaving a few particles of the heavy gold in the sluice boxes.



B

The dredge, back view. The beautiful meadow has become a pile of stones and a few ounces of gold have been won per acre. Those few deadly ounces of gold pay the *cash* value of the meadow in the land market—a few ounces of gold have been won and an acre of land is gone—an acre that might feed a man or two (in Japan it would be 5 or 6) for a thousand years, ten thousand years, or more, and the gold—? Fortunately, but too late, this method of killing the United States is prohibited by law in some states.

tural lowlands with worthless beds of sand and gravel. To prevent this destruction of agriculture, California has wisely passed laws which control and often prohibit hydraulic mining. Much gold is thus made unavailable; but the



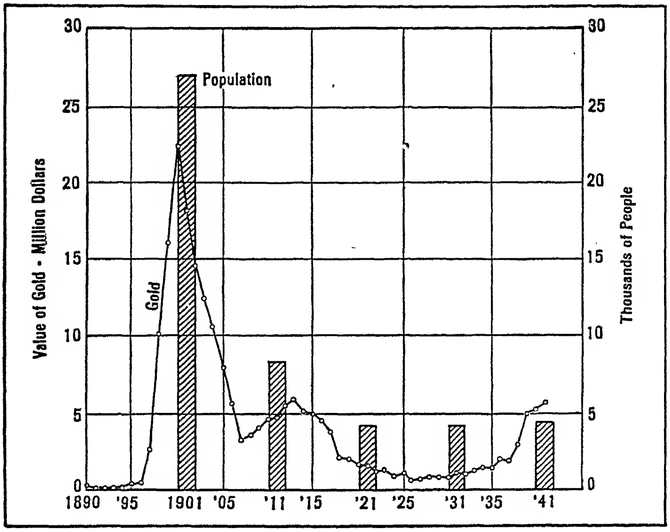
The production of gold in the United States. This apparent explosion in the 1930's was due to the fiat of law. The government jumped the price of gold and land that had not been a resource before had new value added instantly.

farm lands which are saved are of greater value to the community, since the metal-bearing bank yields once while the tilled valley will yield thousands of harvests.

Dredging is another method largely practiced in California, parts of Alaska, New Zealand, Montana, and elsewhere. A dredge resembling that used in deepening river channels takes up the earth in front of it, runs it through sluice boxes, catches the gold and drops the earth behind the dredge.

The most permanent kind of gold mining consists in working the ores that are found in the veins themselves. The ore is usually ground fine by a stamp mill, and then washed by a process similar to that pursued in placer mining. Since washing does not get out all of the gold, the pulverized ore is usually soaked in tanks containing sodium or potassium cyanide, the gold being dissolved and later precipitated on zinc shavings or zinc dust. This cyanide process and other improvements have made it profitable to use ores containing only one-tenth of an ounce of gold per ton. Such technological advancements go far to explain the fact that the world's gold production more than tripled in the twenty years from 1892 to 1912 and then almost doubled again between 1912 and 1941. In 1940 the world's output of gold reached an all-time peak of 42,325,000 fine ounces, yet at a price of $34.95 an ounce this gold was worth less than the American corn crop.

The Uncertainty of Production. Few industries have less permanence in any given locality than gold mining, and it may be that the peak of production for all time has been reached unless political fiat enhances its value again. It may be likened to a fever because of its sudden great activity, its decline, and its intermittent revivals. Rumors of gold discovery start a "rush" of miners from all parts of the world. In the desire to stake out a good claim, it matters not if they must penetrate thick forest, hot desert, or arctic waste. In 1849 men went from every land to California, in 1851 to Australia. In 1897, the news of gold on the Klondike and other streams of the great Yukon system in Canada



Population and gold production, Yukon Territory, Canada. The area of the Yukon Territory is more than twice that of the Island of Great Britain. The Klondike Gold Rush took some miners there, average one person to ten square miles, but concentrated in a few mining camps. The gold was soon dug out and most of the people moved away. Perhaps they will find some more important metals presently. If so, population will rise again—for a time.

and Alaska caused the speedy departure, to that death-dealing land, of miners, professional men, and even women, who struggled with their packs through the snowy passes of the south Alaska mountains into a region of which they knew nothing, to undertake a business of which many of them knew nothing.

The gold of the Yukon was stream gold, easily visible and easily worked by the solitary miner with pick, shovel, and pan. The output of gold increased rapidly, reaching its peak in 1900, and then declined sharply as the easily worked beds were exhausted. Then came the big corporation with large-scale hydraulic methods, with the result that production increased briefly from 1907 to about 1913. One powerful corporation built 62 miles of flume and pipe line to operate placers, and a water-power plant with 36 miles of electric transmission line. Huge dredges are also employed that dig up the gravels, wash them, and drop them into containers. Although higher prices for gold since 1932 have stimulated mining activity, the Yukon output of recent times is but a shadow of its grandeur at the turn of the century.

California, long the leading gold producer in the Union, shows the uncertainties of the industry. The gold discovered there in 1848 was in stream beds. These were soon exhausted, and the miners next discovered many old abandoned river beds and even buried river beds which could be reached by tunneling under lava deposits. Then came placer deposits, and gravel worked by huge floating dredges. Finally, the mother lode was discovered and the

hard ore worked by deep shaft mining. California, which had been surpassed by Colorado with its vein mines, has been the leader from 1911 to date. Dredges produced half of California's gold in 1941.

Relation of Gold to Other Metals. Aside from the gravel and placer deposits, few mines in the United States are worked for gold alone, because gold is generally closely associated with other metals, especially silver, copper, lead, and zinc. Thus most of the mining areas of the west have several mineral products. This is particularly the case in South Dakota, Colorado, Nevada, and Utah which in 1941 ranked after California as gold-producing states. Many mining communities have arisen in remote and almost inaccessible places in the Black Hills of South Dakota and in the lofty Rockies.

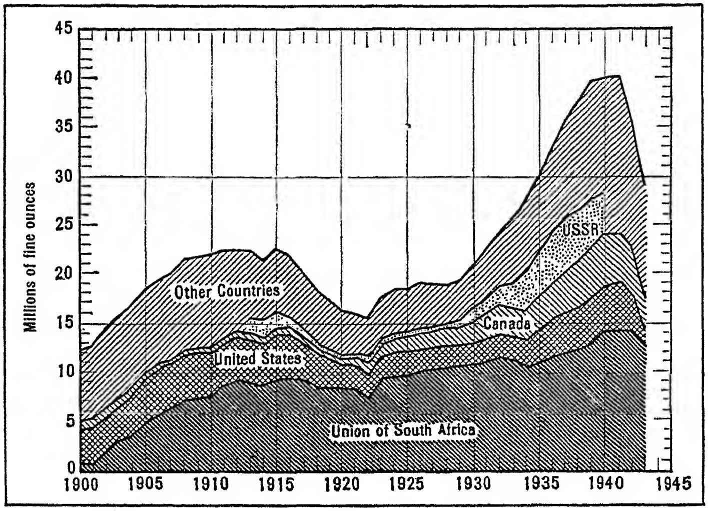
Gold in the Philippines and Alaska. In 1941 two territories, the Philippines and Alaska, accounted for 43% of the total American output of gold.[52] In the Philippines prospecting is made difficult by a heavy overburden of rock, by jungle vegetation, and by inadequate transportation facilities.[53] Most of the mining is now conducted by a few big companies, gold being obtained from both placer and lode deposits. The oldest and most important mining district lies near Baguio in Mountain Province of northern Luzon, other important producers being located on the island of Masbati, near Percale in Camarines Norte of eastern Luzon, in the province of Bulacan east of Manila, and in the provinces of Surigao and Zamboanga on the island of Mindanao. Since 1936 the Philippine Islands have ranked second only to California among American producers of gold.

In Alaska perhaps 1,000 prospectors still wander through valleys and over the hills hoping to strike it rich, but the day of the individual miner is definitely gone. This is shown by the fact that 29% of Alaskan gold in 1941 was obtained from lode mines, 44% was recovered by huge floating dredges, and 27% was secured by the use of dragline and dry-land dredges, bulldozers, sluices, and other placer methods. Approximately three-fourths of all placer gold is mined in the Fairbanks, Circle, Hot Springs, and other districts of the Yukon Basin, while about two-thirds of the lode gold comes from Juneau, Ketchikan, Chichagof Island, and other mining centers in southeastern Alaska. Important production also occurs on the Seward Peninsula around Nome, in the Cook Inlet-Susitna district, in the Copper River area, and on the Kenai Peninsula.

Even with modern equipment, placer mining in Alaska encounters difficult problems. All placer methods require much water, and a dry summer may prove to be a serious handicap. Furthermore, most of the gold-bearing gravels are covered with muck, peat, and other organic debris which insulates the gravel from normal summer thawing. Since the greatest concentration of gold usually occurs just above the bed rock, it may lie deep in gravel that

[52] In 1941 the production of gold, in thousands of fine ounces, was as follows: United States, total —5,976; California—1,432; Philippine Islands—1,144; Alaska—696; South Dakota—612; Colorado—388; Nevada—378; Utah—373.

[53] See William H. Haas (ed.), *The American Empire,* The University of Chicago Press, Chicago 1940, pp. 337-338.



This graph shows the towering position of South Africa, where there was great prosperity after we raised the price of gold. It made black men in Africa feverishly dig it out of the ground, while other men in America dug a hole at Fort Knox, Kentucky, and buried it again. Some people call these black men savages. War pressure upon manpower shows clearly at the end of the graph.

never thaws at all. The problem of thawing out the gold-bearing gravels is now solved by forcing cold water down to the bed rock through pipes that are spaced about 20 or 30 feet apart, this thawing process at Nome and Fairbanks requiring about two to four months. One big company at Fairbanks obtains its water from a source 90 miles away and uses about 200 miles of pipe at the mines.[54] It employs 500 men for the summer, removes about 800,000,000 tons of muck annually, and then moves about 900,000,000 tons of gravel in order to obtain its gold. Alaskan gold-mining of today is a job for the big corporation, not the miner with his pan.

Gold Mining in Africa. Although the United States is rich in gold, its output, excluding the Philippines, is now surpassed by that of the Union of South Africa, Russia, and Canada (see Fig. 231). South African production began in 1884 with the discovery of gold in the Rand district of the Transvaal, and it achieved world leadership in the following decade, a position that it has continued to hold until the present day with the exception of a few years, 1899-1902, when operations were curtailed by the Boer War. The famous Rand district is an area about 50 miles long and a few miles wide surrounding the city of Johannesburg. Without any doubt, it is the most important gold field in all history, for during its comparatively short life its mines have produced about one-fourth of all the gold mined in the world since 1493.[55] This greatest of gold fields lies in a range of long hills in a semi-arid country like New Mexico or Arizona, where other industries are few

[54] *Ibid.*, pp. 187-188.

[55] Joseph Kitchen, "Gold," *Encyclopaedia of the Social Sciences*, vol. 6, The Macmillan Co., New Yo.k, 1931, p. 690.

and communities of hundreds of thousands of people must live by mining alone. The shafts are now about 8,000 feet deep, and since it costs about $9,000,000 to open a new mine, few new ones are developed. However, the old mines continue to expand their underground workings and to increase their milling capacity. In 1940 the Union of South Africa produced 14,038,000 fine ounces of gold, or more than one-third of the world's product, and Johannesburg is now the Union's largest city. Elsewhere on the continent gold production is of considerable importance in Southern Rhodesia, the Gold Coast, and the Belgian Congo, but their combined output is less than one-seventh of that of the Union of South Africa.

Production in Russia. In modern Soviet Russia gold deposits, in common with other natural resources, have been developed on an extensive scale, with the result that since 1934 Russia has come to rank second among all nations as a producer of gold. At the outbreak of World War II, the chief mining areas were in the Aldan and Kolyma river basins of northeastern Siberia, in a climate resembling that of Alaska. Other mining districts are scattered throughout Asiatic Russia and the Ural and Caucasus areas.[56] While both placer and lode deposits have been mined throughout the nineteenth and twentieth centuries, the great bulk of the output now comes from placers that are worked with floating dredges and other modern equipment. In 1938 Russia produced 5,236,000 fine ounces of gold, or about 14% of the world's supply, and, while official data are lacking, it is thought that production has increased considerably since then.

Gold in Canada and Australia. The famous Fraser River rush of 1858 inaugurated gold mining in Canada, and British Columbia was the leading producer from that time until the previously described rush to the Klondike in 1897. Gold mining in the Klondike has declined steadily since that time, and in 1941 less than 3% of the nation's output of 5,352,000 fine ounces of gold came from the entire Yukon and Northwest Territories. About three-fifths of all gold is now mined in Ontario from quartz veins, chiefly in the Porcupine and Kirkland Lake districts. The Porcupine area, only 6 miles square, lies 150 miles northwest of Cobalt; it has been worked since 1912 and is Canada's greatest gold field today. About one-fifth of the Dominion's gold is produced in Quebec, the largest single producer being the Noranda gold-copper mine. Many thousands of square miles remain unsurveyed in Canada's great northern forest, where travel until recently has been confined to the snowshoe, the dog sled, and the birchbark canoe. Today, however, when gold is struck in some remote locality, men and even heavy equipment are flown in at once by airplane, and in the wintertime thousands of tons of machinery and supplies are moved in trains of sleds pulled by tractors across the frozen rivers, lakes, and hills of the Northland.[57]

Australia ranks fifth among the world's producers of gold with an output of 1,625,000 fine ounces in 1940, or about 40% as much gold as was mined in the United States. One of the most

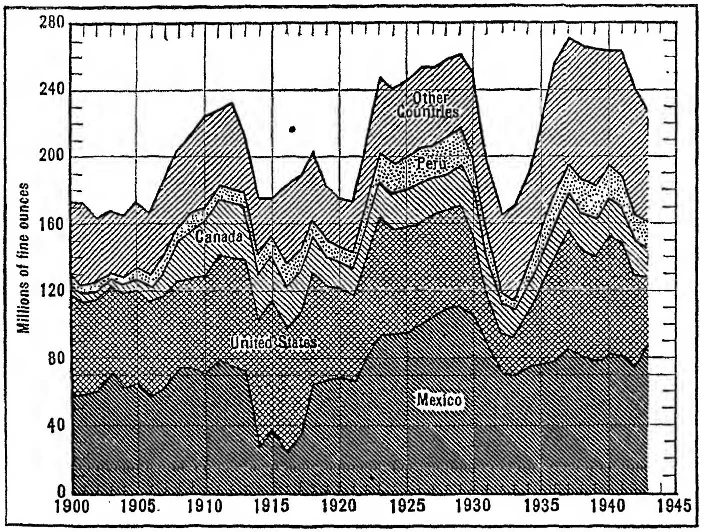
[56] George B. Cressey, *op. cit.*, p. 295.

[57] See J. Russell Smith and M. Ogden Phillips, *North America*, Harcourt, Brace & Co., New York, 1942, pp. 456-458.

exciting chapters of Australia's history was the discovery one after another of rich gold fields—those of central New South Wales in 1850, Ballarat and Bendigo (Victoria) in 1851, Mount Morgan (Queensland) in 1882, Kimberley in 1886, Coolgardie in 1892, and Kalgoorli in 1893, the last three in Western Australia. Miners flocked to the new diggings, many of them deep in the Australian desert, and water was in one case brought a distance of 360 miles by pipe line. So great has been the imprint of gold mining upon the nation's history that Australians today often hail each other as "Digger," in spite of the fact that Australia no longer enjoys the preeminence in gold mining that it did in the early years of the century. Indeed, Australia's share of the world's gold output has fallen from one-fourth in 1903 to one-fortieth in 1940, and the number of men engaged in mining dropped from 70,000 to 18,000. About four-fifths of the country's gold is now mined in Western Australia, and the individual miner and prospector have been succeeded by the mining company with its machinery. In Victoria the deposits discovered in 1851 have now been worked to a depth of more than a mile. Unless new deposits are discovered—the vast uncharted wastes of the interior make such a discovery not improbable—Australia is faced with a steady decline of her gold-mining industry.

Gold in Latin America. The mountains of western America from the United States to Chile are rich in gold and also silver, which have been alike a curse and a blessing to those regions. They urged on the conquest by the Spaniards and for many districts have been the chief basis of commerce since the discovery of America. The Spanish succeeded in getting gold by enslaving the people, one-half to work the mines, and the other half to produce food for the miners. In Peru, Mexico and other parts of the Americas, the Spanish taskmasters got huge quantities of gold. Throughout the mountain districts only the best vein deposits could be worked and by the crudest hand methods, so that in many parts of the Andean region and in much of Mexico numerous deposits, although worked for many decades, may now be considered as new fields, in view of modern improvements in methods of mining, which, however, demand the railway for their effective operation. Indeed, many an abandoned mine has been profitably reworked with modern mining methods. Mexico has led all the other Latin American countries in the development of gold mining with an output of 800,000 fine ounces in 1941, nearly all of which was mined in the states of Hidalgo, Chihuahua, Durango, Michoacán, Zacatecas, and Guanajuato. Mexico, however, is far more famous for its silver than for its gold. Indeed, in recent years the combined gold output of all Latin American nations has been only about twice that of the Philippines or Australia.

The mineral resources of the South American continent, nearly the equal of North America in size, are still largely undeveloped. Thus far the modern operations in South America have been chiefly limited to regions where a temperate or dry climate prevails, as in the mountains of Colombia, the lofty plateaus and mountains of Peru, and the Chilean desert. Among the Latin Amer-



Examination of this graph shows the tremendous leadership of America, especially North America, in the production of silver, but the greatest market for silver is the countries of Asia, where it is used as currency.

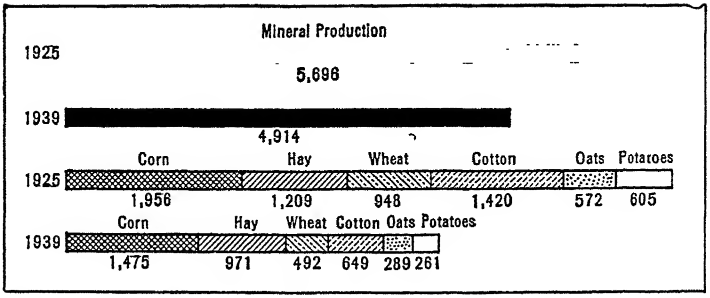
ican producers of gold, Colombia ranks next to Mexico, with an output of 650,000 fine ounces in 1941, most of which was mined in the interior provinces of Antioquia, Cauca, and Caldas. In Chile and Peru most gold is obtained as a by-product of copper and silver mining. Gold production of lesser importance also occurs in the Guiana highlands of Venezuela, near Bello Horizonte in the southeastern plateau of Brazil, and in the mountains and plateaus of Bolivia. While South America produces only one-seventh as much gold as North America, the surface has been scarcely scratched, and the potential resources are probably great. One of the best ways to appreciate the advantages and possibilities of the present machine epoch is to remember that ordinary mining stops at the level of ground water unless power pumps remove it.

8. *Silver*

Little Relation Between Output and Price. In recent years Mexico, the United States, Canada, Peru, and Australia have continued to mine about three-fourths of the world's annual output of silver, which in 1940 reached an all-time peak of 275,071,000 fine ounces (see Fig. 234). In contrast with most other commodities, the production of silver does not respond readily to an increase or decrease in its price, because about three-fourths of the world's silver is mined in conjunction with copper, lead, zinc, and other metals.[58] Most of the silver that is mined today is distinctly a by-product of complex ores that owe 50% or more of their value to other metals found in these ores.[59] In contrast, Mexico is the only country that now produces the bulk of its silver from sil-

[58] Herbert M. Bratter, "Silver," *Encyclopaedia of the Social Sciences,* vol. 14, The Macmillan Co., New York, 1934, p. 58.

[59] More than one-half of the world's output of silver comes from ores that derive less than 40% of their value from the recoverable silver, while



Here is an interesting comparison of the cash value of mineral production and agricultural production in the United States.

ver ores. As a consequence of the growing industrial demand for the baser metals with which silver is associated, the improved technique in recovering metals from ore, and the discovery of new deposits, the world's output of silver increased from 78,000,000 fine ounces in 1880 to 228,000,000 fine ounces in 1913, and to 267,000,000 fine ounces in 1941.

Mexican Leadership in Production. Mexico has long been the world's foremost producer of silver, its output of 78,364,000 fine ounces in 1941 amounting to 30% of the world's supply. The nation's greatest silver mines are those of Pachuca, which have been worked for centuries and now yield most of the silver produced in the state of Hidalgo. Other important centers include Chihuahua, San Francisco del Oro, Parral, and Santa Barbara in the state of Chihuahua and the Fresnillo and Mazapil districts in Zacatecas. From the mines of Hidalgo, Chihuahua, and Zacatecas came 70% of Mexico's silver in 1941. In the smaller and more primitive mining areas an ancient device is still used—the arrastra, a stone floor on which ore is crushed by a stone wheel, rolled around upon the ore by beasts of burden. From the crushed ore the silver collects in the cracks of the stone floor and in the concentrated form is carried scores or even hundreds of miles on pack mules. The building of railways and highways in Mexico has made it possible for the large mines to use the most improved machinery and processes, and has caused rapid increase in the output of silver and other metals. Mexico probably depends more for prosperity on minerals than any other country, except Chile.

The American Silver Industry. In the United States, second to Mexico in output, silver mining depends for its prosperity upon the output of gold, copper, lead, and zinc,[60] since silver is largely a joint product of such mines. The mines operated for silver alone are relatively few. Idaho is the leading silver mining state, followed by Utah, Montana, and Arizona. The total output of

about one-third of all silver comes from ores that owe less than 20% of their value to the silver content. Hence, as industrial activity expands the demand for copper, lead, zinc, etc., the output of by-product silver is increased with little or no regard for its market price.—*Cf. ibid.* and Erich W. Zimmermann, *World Resources and Industries,* Harper & Brothers, Publishers, New York, 1933, pp. 736-737.

[60] The largest producer of silver in the United States is the Anaconda Copper Mining Company of Montana, the silver being obtained from its copper and zinc-lead ores.

silver in the United States, excluding the Philippines, in 1941 amounted to 71,076,000 fine ounces and was worth about $50,000,000, or less than the value of the corn crop of Tennessee, which is exceeded by 9 other corn-growing states.

Canada, Peru and Australia. Canada, the third producer, gets nearly half of its 21,275,000 fine ounces from British Columbia, chiefly from the rich lead-zinc-silver mine at Kimberley. More than one-fifth of the nation's silver was mined in Ontario, principally in the Sudbury and Cobalt districts, while most of the remainder was produced in Saskatchewan, the Yukon Territory, and western Quebec.

Peru, with an output of 15,101,000 fine ounces, produced more than half of all the silver in South America in 1941. The greatest mining district lies at an elevation of 14,700 feet at Cerro de Pasco, and the mines, which have been worked for more than 300 years, yield most of the nation's silver, copper, and gold.[61]

Most of the Australian silver output of about 13,000,000 fine ounces is mined in the great Broken Hill district of western New South Wales, which is also famous for its zinc and lead, and much of the remainder of the country's silver comes from the Mount Isa district near Cloncurry, Queensland. Other silver mining countries of lesser importance are Japan, Russia, Bolivia, and Burma.

Industrial Importance. Silver is more abundant and cheaper than gold, and its industrial uses are more numerous and varied. Between 1901 and 1941 the net industrial consumption of silver in the United States increased from 12,900,000 to 72,400,000 fine ounces.[62] In 1941 approximately 30,000,000 fine ounces of the metal were devoted to the manufacture of sterling silverware, which has been the principal industrial use of silver for many years. Other important markets for silver include the photographic industry, the electroplating industry, the manufacture of jewelry, optical goods, and novelties, and the production of silver-lined steel tanks and other equipment for the chemical industry. During World War II, much greater use was made of silver in the production of solder and brazing alloys, and it often replaced nickel and chromium for metal plating and much of the tin in babbitt metal. However, in spite of the growing industrial uses of silver, much of it is used for monetary reserves and subsidiary coins. Scarcely a year goes by without some representative of the silver industry publicly advocating either the unlimited coinage of the metal or that the United States Government should increase its purchases of silver. The silver industry has never lacked special pleaders in this and foreign countries. The function of silver in American politics is one of the humiliating chapters in the economic interpretation of history.

9. *Platinum*

Properties and Uses. Platinum is a metal that is more costly than gold; it is heavier and more ductile than copper,

[61] At Minasragra, near Cerro de Pasco, are the world's largest vanadium mines. For an account of the difficulties of mining in this area, see Preston E. James, *Latin America,* The Odyssey Press, New York, 1942, pp. 156-157.

[62] Industrial use fluctuates considerably, amounting to 23.1 million fine ounces in 1913, 31.0 millions in 1929, and 20.2 millions in 1938.—See U. S. Dept. of Interior, *op. cit.,* p. 61.

silver, or gold; it has a high melting point (3,190° F.) and a tensile strength of 42,000 pounds per square inch, and it resists the action of alkalies and most acids. Because of these qualities, platinum has come to be used increasingly in jewelry, in the chemical and electrical industries, and in dentistry. In normal times about half of all the platinum consumed in the United States is used by the jewelry trade, although in 1941 its major market was the chemical industry which utilizes the metal in the production of sulfuric and nitric acid and for many other purposes.

Production. Platinum was first discovered in Colombia, and it has been mined for more than 200 years. The metal is obtained as a by-product in the mining of copper, nickel, and gold, as in the Sudbury district of Ontario where about one ounce of platinum is recovered from every 20 tons of ore, and much of the metal is mined from placer deposits, as in Russia, Colombia, and Alaska. Closely allied with platinum are other platinum metals, namely, palladium, iridium, rhodium, ruthenium, and osmium. These are generally similar to platinum but have particular qualities that enable them to serve in specialized uses. Thus, rhodium has been called "the diamond of metals," for it is one of the whitest and hardest of all metals and never tarnishes; hence, rhodium plating is used for surfacing reflectors in powerful searchlights and as a finish for jewelry and silverware. Iridium and osmium, because of their hardness and resistance to corrosion by ink, are used in the manufacture of points for higher-priced fountain pens. However, the most widely used metal in the group is platinum itself, which accounts for as much as two-thirds of the consumption of all platinum metals.

Of the world's total output of 531,000 troy ounces of platinum metals in 1939, about 53% was mined in Canada, 20% in Russia, and 12% in the Union of South Africa, nearly all of the remainder being produced in Colombia and Alaska. The world's greatest platinum mining districts at the present time are those of Sudbury, Ontario, and of Nizhni Tagil in the Urals of Russia. The United States is dependent upon foreign ores, principally from Canada, for the great bulk of its supply. In 1941 this country imported 310,000 troy ounces of platinum metals, it produced 52,000 ounces of secondary metal from scrap, but it mined only 27,000 ounces, most of which was derived from the placer deposits of the Goodnews district in southwestern Alaska.

10. Diamonds

For centuries the diamond has been the most valued of all precious stones, as the brilliance and sparkle of a skillfully cut diamond make a tremendous appeal to those who love gems and can afford to buy them. The first diamonds were mined more than a thousand years ago in India, Hindu lapidaries learning to use wheels coated with diamond dust to cut the hard stone. The secrets of the art were carefully guarded, being transmitted from father to son, and it was not until about 1460 A.D. that the art was introduced into Europe, where Portuguese, Belgian, and Dutch artisans came to surpass their Oriental confreres in skill.

Sources of Supply. In 1721 diamonds were discovered in quantity upon the

interior plateaus of the state of Minas Geraes, Brazil, and in 1732 the first large shipments reached Europe. Brazilian diamonds were panned by miners from the beds of streams where they had been left by the same process which leaves gold, namely, the washing down of the mother lode. For a century and a half the washing out of these alluvial diamonds made Brazil the leading producer. In 1867 alluvial diamonds were discovered in South Africa, and in 1870 the finding of several so-called diamond pipes near Kimberley in the Transvaal enabled South Africa to vastly outdistance Brazil. These pipes are imbedded in volcanic rock and are mined at great depths today. The diamond-bearing rock is lifted out, crushed, washed in pans, concentrated in jigs, separated on grease tables, and carefully graded by sorters. In order to prevent the native workmen from stealing and carrying the diamonds out of the mines, they are kept on the premises almost like prisoners during the term of their labor contract. In 1940 South African pipe mines yielded a diamond output of 351,000 carats, and 172,000 carats were obtained from alluvial deposits. While the Union of South Africa led the world in diamond production from 1872 until 1931, in recent years its output has been greatly surpassed by that of the Belgian Congo, the Gold Coast, Angola, and Sierra Leone.[63]

The present century has witnessed the discovery and development of a number of outstanding diamond fields. In 1907 great deposits of alluvial diamonds were found in the upper Kasai River valley in the Belgian Congo about 200 miles north of the Angolan boundary. However, it was not until 1913 that the first shipment of 15,000 carats was made to Antwerp, for the jungle had to be cleared away, native tribes pacified, a labor force recruited, and elaborate machinery installed before production could begin. In recent years about 11,000 Negroes and 150 white men have been employed in the Congo diamond fields. The efficiency of labor has continued to improve, much of the overburden is now removed by hydraulic giants, and many of the plants utilize hydro-electric power. The companies operating in this area keep a large gravel reserve blocked out, thereby insuring a longer productive life. By 1933 the Congo fields had produced a greater quantity of diamonds than the all-time production of India or Brazil. The Belgian Congo is now the world's foremost diamond producer, on the basis of both weight and value, its output in 1940 amounting to 10,900,000 carats.[64]

Important discoveries were made in the Diamang field of northeastern Angola (Portuguese West Africa) in 1908, the Birrim Valley district of the Gold Coast in 1919, and the Kenja and Kono districts of Sierra Leone in 1930, and each of these countries now produces a larger quantity of diamonds than the Union of South Africa or Brazil, former

[63] The world's greatest diamond mine is the Premier Mine near Pretoria, where in 1905 a mine foreman found the world's largest diamond which weighed 3,106 carats, or 1⅓ pounds. The value of all diamonds produced in the Union of South Africa prior to January 1, 1942, was £331,922,500, or about 18% of the value of the Dominion's total output of gold.

[64] In 1940 the Belgian Congo produced 77% of the weight and 24% of the value of the world's total output of 14,140,000 carats, or 2,828 metric tons, worth about $31,000,000. The production of diamonds in other leading countries, in thousands of carats, was as follows: Gold Coast—825 Angola—784, Sierra Leone—750, Brazil—325.

leaders in the industry.[65] It is purely geological chance that about four-fifths of the weight and half of the value of the world's diamond output now comes from tropical countries. It is estimated that if it were not for medical research and modern sanitation, the present output would be at least one-third smaller than it is. A century ago 100% of the world's production came from the tropics where disease decimated the workmen, and experts risked their lives in visiting the diamond fields. Today malaria no longer saps the vitality of men, dysentery is rare, and sleeping sickness is being conquered. In 1938 one company in the Belgian Congo brought in a large, mobile medical staff which examined 129,348 natives and treated those infected with sleeping sickness. Throughout the Belgian Congo the number of cases of this dread disease has declined from 11 per 1,000 persons in 1908-10 to only 2.9 per 1,000 in recent years.

Diamond Cutting. While smaller diamonds are employed in the manufacture of various drills, dies, and tools, diamond dust being used for dressing emery wheels, the bulk of the world's diamond output is generally destined for the jewelry trade.[66] The diamond is a prism and has a high refractive index that causes it to split the white light of the sun into all the colors of the spectrum, but its brilliance and sparkle, so desirable in jewelry, depend largely upon the skill with which the diamond is cut.[67] In prewar years Antwerp was the greatest of all diamond-cutting centers with about 20,000 to 25,000 artisans, while about 5,000 cutters were employed in Amsterdam and 4,500 in Hanau and other German cities. Minor cutting centers included New York, London, Paris, Geneva, Capetown, Johannesburg, Rio de Janeiro, and several cities in India and Borneo. During World War II the industry was badly disorganized, and New York temporarily became the diamond-cutting center of the world, with some 650 cutters and a large number of apprentices, the more experienced cutters earning over $235 a week. Since the diamond is a luxury, the mining and cutting of diamonds are keenly sensitive to fluctuations of demand during periods of business prosperity and depression.

The Diamond Monopoly. Of all he mineral industries, none is subject to such strict, monopolistic control as are the production and sale of diamonds.[68] One lone firm, the Diamond Corporation of London, now controls about 95% of the world's output, and it is able to restrict production, restrict sales, maintain high prices, and force the market to clamor for diamonds. This corporation sells diamonds to only a few of the very best cutters from the leading diamond-cutting centers, and they must deal through a small group of London brokers approved by the corporation. When a shipment of diamonds is to be sold, the brokers are notified. A broker

[65] The leading Brazilian district is near Diamantina, Minas Geraes, much of the output consisting of small gems and industrial diamonds. However, in 1941 the huge Vargas diamond was found; it weighed 726 carats and was subsequently cut into 23 gems, the largest weighing 21.6 carats.

[66] Under the stimulus of wartime demand, the world's consumption of industrial diamonds amounted to 7,500,000 carats in 1942.

[67] For an interesting account of the diamond-cutting industry, see "Diamonds," *Fortune*, vol. 11, June, 1935, pp. 96-100 ff.

[68] See Charles K. Leith, James W. Furness, and Cleona Lewis, *op. cit.*, pp. 126-130, and "Diamonds," *Fortune*, vol. 11, May, 1935, pp. 67-74 ff.

who has an order from a particular client applies for a "sight" of the kind of stones wanted. If permission is granted to see them, the broker is given a parcel of stones containing a selection that suits the convenience of the corporation. The broker must buy the parcel *en bloc,* or not at all, and he will take it if he wishes to continue business with the corporation. However, the customer can usually sell such stones as he does not need on the diamond markets of such great centers as Antwerp and Amsterdam. Since 1889 this great corporation has never failed to extend its control over every new diamond field of importance, and it has been able to persuade both governments and private interests to accede to its judgment in matters of production, sales, and prices. Wealthy Americans, of course, pay a large part of the bill!

In 33 years, the De Beers Company of Kimberley paid in dividends at an average rate of 34.8% on the par value of its capital stock. This is a good example of success in that great and growing objective of industry—keep your product relatively scarce. Abundance is the devil of the Machine Age. The diamond company has made a perfect escape from this Satanic majesty.

. . . 9

Non-Metallic Mineral Building Materials

1. The Early Use of Non-Metallic Minerals

Stone, clay, sand, and gravel are such common resources that their significance in the equation of human development is frequently overlooked. Paleolithic man was a migratory soul who searched for food, made his clothes, and sought shelter in a hurry. This hairy hero of primitive times made effective use of wood, hides and skins, bone, and stone. Often he lived in a cave, a home of stone hewn by nature. A stone clutched in his fist was man's first hammer. Sharpened by chipping and polishing and attached to the end of a stick, the stone became an ax. With the patient polishing of stone tools and weapons, man emerged from the Paleolithic or Old Stone Age into the Neolithic or New Stone Age. About this time some unknown artisan fashioned pottery from clay, thereby enabling man to live at a greater distance from his source of water and to cook his food in vessels more permanent than bark. Thus, stone and clay were common resources long before man made first use of copper and other metals. With the development of sedentary agriculture, pottery was greatly improved; perhaps the plowing of fields led to the discovery of new and better clays. At about the dawn of written history, the arts of making bricks from clay and glass from sand were developed, and later came the use of mortar and cement. From prehistoric antiquity until the present day, the non-metallic minerals have made important contributions to the satisfaction of human wants and to the advancement of civilization.[1]

The scarcity of wood and the resulting increase in the price that came with the twentieth century are forcing the people of America, like those of older countries, to find building materials in the earth's crust. After our nineteenth-century saturnalia of tree slaughter and cheap wood, we are being driven more and more to adopt the building materials used in Ancient Rome and used now in most parts of Europe, east Asia, and north Africa. It is a sign of the declining ratio of land to man that necessarily accompanied the increase of population and the end of the frontier period.

[1] It is not easy to evaluate the influence of any mineral or group of minerals upon the course of history. A strong man with a club may have been superior to the unskilled wielder of the finest blade of steel ever forged at Damascus or Toledo. King Pyrrhus, after staggering the armies of Rome, was killed by a well-aimed brickbat. Fortifications made of stone have repulsed attacks or have yielded, depending upon their location, the manner in which they were built, and upon the number, skill, and bravery of their defenders. Knowledge, skill, technique and dumb chance go hand in hand with tools and equipment in shaping human events and the course of civilization.

Rome had these conditions, and cement was more largely used there in the days

This gigantic piece of cement work is a spillway to carry surplus water harmlessly away from the Boulder Dam. Such a thing, like the Dam itself, would have been impossible before the coming of concrete. It makes a startling comparison with the primitive vessels of earth material that came out of the period that we call pre-historic.

of the Empire than at any time prior to the present. The whole Roman world still bristles with its remains.

2. *Clay and the Brick and Tile Industries*

Development of Brick and Tile Manufacture. Clay in the form of burned or unburned brick has commonly been the first resource of peoples with whom wood was scarce, especially in arid countries. Houses of adobe or sunburned bricks have been widely used from Pharaoh's time to the present, and adobe is still a common house material through western Asia, north Africa, parts of south Europe, southwestern United States, Mexico, and some of the Andean section of South America. In these countries the mild winters (freezing tends to disintegrate brick and stone) and the small rainfalls permit such a building material to suffice. In the middle temperate latitudes, brick must be hardened by burning clay and shale to make them endure, and they become by this process more durable than many kinds of stone.

Location of the Brick and Tile Industry. While brick-making in this country began as early as 1611 in Virginia and 1629 in Massachusetts, its outstanding development occurred during the latter half of the nineteenth and early years of the twentieth centuries. As the nation's population increased, there developed a rapidly growing demand for bricks in the construction industry, particularly in towns and cities where the increasing size and height of buildings called for stronger structural support and where bricks came to be used extensively for paving streets. Thousands of miles of tile were needed as sewer pipe in the cities and for the drainage of level land in rural areas. Later the construction industry came to use larger amounts of hollow tile, roofing tile, terra cotta, and other fire-clay building products. In response to the growing demand, the brick and tile industry expanded its output at the rate of about 40% to 50% per decade, reaching its highest peak in 1909.[2] While the output varies with seasonal and cyclical fluctuations in demand, the long-run trend in

[2] Evan B. Alderfer and Herman E. Michl, *Economics of American Industry*, McGraw-Hill Book Co., Inc., New York, 1942, p. 191.

production since 1909 has been downward, due largely to the remarkable increase in the use of cement and structural steel in the construction industry.[3]

The low value and great bulk of bricks make them relatively and absolutely expensive to transport. Then, too, the clay suitable for making them is very common, so that the industry can be located near the cities that furnish the market for bricks. In its wide distribution in response to scattered demand, the making of common brick resembles the production of fresh milk. Of the total output of $78,153,000 in 1939, twenty-three states had each over $1,000,000 worth, and but six over $3,000,000. The states with the largest output are those with large population—Ohio, Pennsylvania, New York, and Illinois. The leading brick-making districts are those of the Hudson River Valley and Cook County, Ill., near the great metropolitan areas of New York and Chicago. The New York industry has its chief development in the Hudson Valley between New York City and Cohoes where both railroad and river navigation furnish easy access to the enormous market of the cities about the mouth of the Hudson River.

It is only occasionally that long transportation of brick is warranted because of some special quality of the bricks. Such are the widely disseminated yellow bricks made in Milwaukee, Wis., Winslow Junction, N. J., and elsewhere and also the vitrified brick made so largely in the Ohio clay belt. The bricks of special quality above mentioned are for facing fine houses. Others called fire bricks are very resistant to the fusing effects of heat and are used to line blast furnaces and other heated receptacles used in metallurgy. Some of the best clay for this purpose is found beneath the Appalachian coal seams and the most important fire brick center is in the western Pennsylvania coal field.

When ocean transportation is available, bricks of no special quality occasionally may be taken great distances, chiefly as ballast for vessels. For this reason lumber and tobacco ships of the eighteenth century brought back many cargoes of English bricks, which the farmer's otherwise empty wagon hauled surprising distances where they may still be seen in the old colonial structures of the Tidewater region of the Atlantic States. In the same way Belgian and British bricks are yet carried to Argentina. But the brick yard, with its smoking kilns and clay-mixing machines that masticate the clay, shoot out the bricks by the mile, and cut them off into lengths, is usually an industry that is limited to a local market.

Drain tile is a cheap and bulky product that is difficult to transport because it is porous and weak. Hence, it is manufactured in close proximity to the market, nearly three-fourths of all drain tile in this country being produced in Iowa, Illinois, Indiana, and Ohio. This tile serves as a sort of field sewerage system to carry off surplus water from the flatlands of the North Central States, mak-

[3] The record output of 1909 was about equaled in 1925, when this country produced 7.6 billion common bricks worth $88,600,000, 2.5 billion face bricks worth $45,400,000, and 0.5 billion vitrified bricks worth $11,900,000, the total value of sewer pipe, hollow building tile, architectural terra cotta, and other fire-clay building products amounting to $147,100,000. In 1938 the nation's output was approximately one-third that of 1925. —U. S. Dept. of Commerce, *Statistical Abstract of the United States, 1942*, Washington, 1943, p. 881.

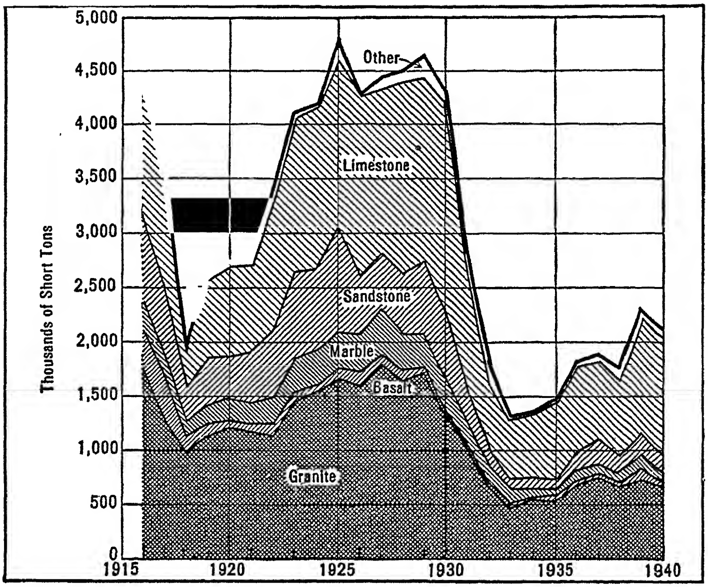
ing these lands fit for tillage soon after each rain.

In a treeless and stoneless country like Holland, such earth products as brick and tile are very important. Most of the houses of that country are roofed with a beautiful red clay tile, and one of the favorite interior house decorations is a glazed blue tile called Delft ware from the little city that for centuries has been well known throughout the western world because of this ware.

3. *Granite, Marble, and Slate*

The Quarrying Industry. Although brick must be manufactured and stone merely taken from the earth, the building stone is often more expensive to use because of the large amount of labor involved in quarrying and shaping stone, or in fitting rough stones together in the wall. The great weight of its product and the widely scattered deposits of stone make the quarrying industry, like the production of brick, tend to be local, that is, near the consuming markets. Exceptions are found in several places in the United States where stones of peculiar merit or unusual accessibility give rise to large quarrying industries with a distant market. For this reason, New England has

The rays of sunshine illumine one of the deep pits of a Vermont marble quarry. The smooth cut surfaces show the efficiency of the almost unbelievable hardness and resistance of modern steel.



The sales of dimension stone in the United States, 1916-1940, show that this kind of building material does not experience war booms—indeed quite the opposite. The haste of war blasts rock, crushes it and pours concrete.

important quarrying industries along the seacoast where the scraping glaciers have exposed bare hills of slate, limestone, and granite. These quarries have access to the best possible transportation facilities, namely, that afforded by the sea-going vessels that can come amazingly close to the side of the quarry in many sheltered bays upon the indented coast.

Likewise, in Europe cheap water transportation plays an important role in the shipment of heavy building stone to market, the excellent granites of Scotland, Norway, Sweden, and Finland being quarried near or along the coast and shipped to the plains countries of western Europe, where stone is scarce, to be used for building and paving materials. The solid Alps give abundant supplies of granite, in great demand in the home country and in the Rhine Valley. Rhine boats, which bring to Switzerland coal, grain, cotton, and other raw materials for her dense population, take a return cargo of stone for the alluvial lands of Belgium, Holland, and Rhenish Germany, districts nearly devoid of stone. The Dutch dykes which keep out the sea are, in part at least, constructed of Swiss granite brought in the Rhine boats.

Granite. This is an extremely hard, weather-resistant crystalline rock that takes a fine polish and which has long been used as a building material and for monumental purposes. In 1941 14,300,000 tons of granite were quarried in the United States, but only 782,000 tons were sold as "dimension stone," or granite that was cut to size for use as monuments, building stone, paving blocks, and curbing. The great bulk of the output was sold as crushed or broken stone

for construction work, including "rip-rap" for use in walls and foundations. The nation's granite output was worth $25,000,000, the quarry value of dimension stone amounting to 43% of the total.[4] At the present time Barre, Vt., St. Cloud, Minn., and Elberton, Ga., are the leading producers of monumental granite, the famous "Rock of Ages" granite of Barre being found in almost every cemetery in eastern America.

In Europe quarrying is more important relatively and much more important absolutely than in the United States, for reasons arising from the number and density of population and the scarcity of forests. In commercial quarrying, Switzerland is the New England of Europe. There, as in New England, there is dearth of other resources and great abundance of stone.

Italy, so poor in wood, probably has a greater domestic dependence on stone than any other country. Houses with second and third story floors made of stone supported on arches are common, and they killed tens of thousands of sleepers in the Messina earthquake of 1912.

Marble. In south Vermont near Rutland is one of the greatest marble industries in the world. As in other extensive quarries, the rock is cut and lifted by mechanical methods, and the product is sent surprising distances when one considers how many other good marble deposits there are in the United States. It is a tribute to Yankee energy. There are unused deposits around the Great Lakes, especially Huron, and in many parts of Appalachia. Fine marble is produced in Georgia and Tennessee, and Colorado quarries are now being worked in the sides of whole mountains of white marble. The most famous of all marble districts in the world is that at Carrara not far from Leghorn in Italy. This district has furnished practically all the world's statuary marble for several centuries and, in addition, much beautiful building stone.

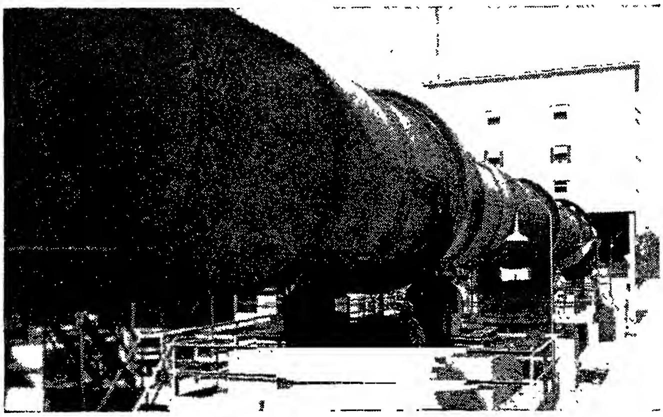
Slate. Slate has long been popular as a roofing material for higher-priced homes because of its rustic appearance, durability, and fireproof character. Dimension slate that has been quarried, slabbed, and split to size is also used in blackboards, billiard-table tops, grave vaults, and electrical apparatus. However, the greatest tonnage of slate is used in the form of granules for surfacing prepared roofing and in the form of slate flour for the manufacture of roofing mastic, oilcloth, linoleum, and fillers in paints. About three-fifths of all slate in this country is quarried in Pennsylvania between Slatington and Bangor, most of the remainder being produced in Vermont, New York, and Maine.

4. *Limestone, Sandstone, and Trap Rock*

Limestone. Of all the stones that are quarried in the United States, limestone is the most important, its sale of 133,200,000 tons worth $127,000,000 in 1941 far surpassing that of any other stone.[5]

[4] Vermont, Georgia, and Massachusetts are the leading producers of dimension stone. In recent years the famous quarries of Quincy, Mass., have suffered a serious decline. North Carolina, Georgia, and California led in the quantity of crushed and broken granite—the *tonnage* greatly exceeding Vermont and Massachusetts.—See J. Nelson Clifford, "Granite Industry of Quincy, Massachusetts," *Econ. Geog.*, vol. 15, April, 1939, pp. 146-152.

[5] In 1941 the weight and value of other stone sold in the United States was as follows: basalt and related rock (trap rock), 17.9 million tons,



This gigantic pipe is really a tubular furnace called a cement kiln in which the powdered shale and limestone are burned with natural gas or powdered coal. The fuel is blown in at one end and drawn out at the other. So is the charge of raw materials. As these materials pass through the kiln, the kiln rotates and drops its materials repeatedly through the current of flame and hot gases. This mechanically tended furnace combines with a series of elevating devices and grinding machines to give us cement at the almost unbelievable low price that we actually have to pay. The wide distribution of the three materials keeps us from the exactions of an unreasonable monopoly.

vania, and New York are now the leading producers of sandstone.

The dark-colored igneous rocks known as trap rock, chiefly basalt and diabase, are too hard to trim for building purposes, and their color is not attractive. Nearly all of the trap rock is crushed and used for surfacing roads. The quarries of New Jersey, Oregon, and Connecticut produce about 40% of the nation's output.

5. *The Cement Industry*

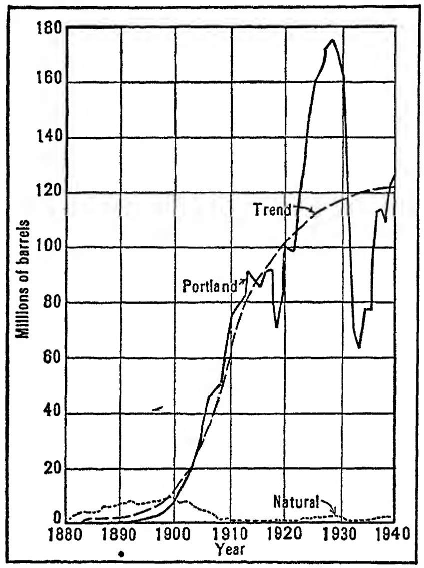
Puzzolan Cement. We know that cement is an enduring building material, for it was one of the materials employed by the Romans in constructing aqueducts, bridges, roads, and some great buildings that are still standing.[6] Chunks of ancient concrete are still to be found in the wheat fields of Tunis, Spain, and other parts of the once far-flung Roman Empire. This cement of Roman times, known as *puzzoalana,* was made by mixing slaked lime with volcanic ash, and this industry still operates on the flanks of Mt. Vesuvius. During the Middle Ages cement-making was virtually unknown, and not until the closing years of the seventeenth century, when many fortifications were being built, did modern man develop from various rock materials a product that closely resembled the ancient *puzzoalana.* Today puzzolan cement is made by mixing slaked lime and granulated blast furnace slag, and natural cement is made from cement rock that needs only to be burned and

[6] See Edwin C. Eckel, "Cement," *Encyclopaedia of the Social Sciences,* vol. 3, The Macmillan Co., New York, 1930, p. 286.

pulverized. Natural cement was used in this country as early as 1820 in the construction of the Erie Canal, and prior to 1900 it comprised over 60% of all cement manufactured in the United States.[7] Today, however, puzzolan and natural cements amount to less than 2% of our total cement production.

Portland Cement. The great cement of modern times is Portland cement, which was first made in 1824 by Joseph Aspdin, a bricklayer of Leeds, England.[8] Portland cement is now made by burning powdered limestone with clay or shale to a temperature of 2,800° F., coal, petroleum, or gas being used as fuel. The resulting clinker is then ground so fine that it will pass through a screen with 40,000 openings per square inch, and a small amount of gypsum is usually added to the finished product to slow down the rate of hardening. The manufacture of Portland cement is a highly complicated process, involving some 80 different operations, the use of heavy and expensive machinery, and rigid laboratory testing in order to insure a uniform product. When cement is mixed with sand, gravel, slag, and water, the whole mass hardens into artificial stone known as concrete. Since concrete can be poured into almost any shape, it has a unique advantage over all other building materials.

The advent of what is sometimes called the cement age in America was ushered in by the perfection of the rotary kiln during the later years of the nineteenth century. This machine greatly reduced labor costs and enabled production on a large scale, the price of Portland cement declining from $3.00 a barrel in 1880 to $1.50 a barrel in 1941. Among the factors that contributed to the rapid increase in cement production during the present century were the growing scarcity and higher price of



This graph of cement production shows how astonishingly new the industry is and that this industry also is a peacetime boomer rather than a wartime boomer.

wood, the adoption of specifications leading to the manufacture of uniform cement generally acceptable to consumers, the use of steel wire and rods to reinforce concrete, and the expansion of automobile production which resulted in the construction of a tremendous mileage of concrete highways. As a consequence, the manufacture of cement in the United States increased from 17 million barrels in 1900 to 167 million barrels in 1941.

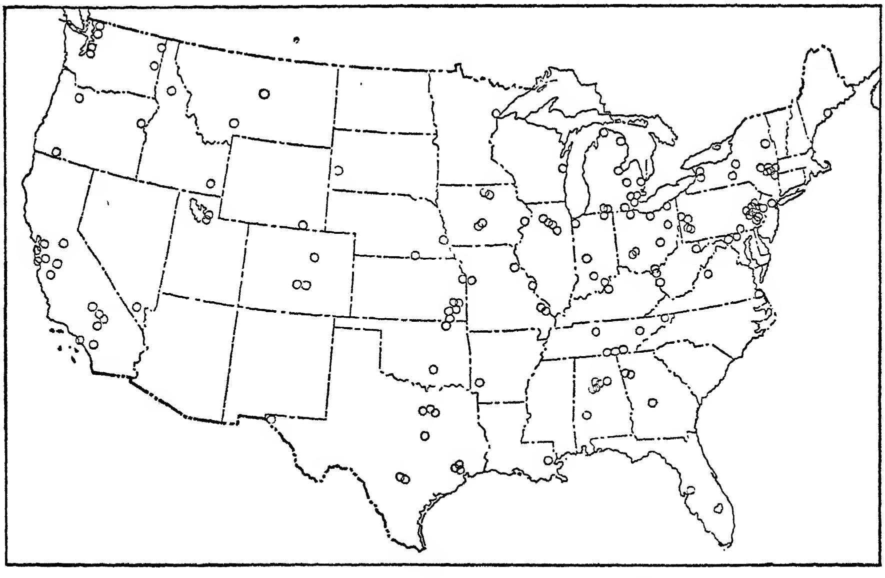
It will take us many years to appre-

[7] Evan B. Alderfer and Herman E. Michl, *op. cit.*, p. 174.

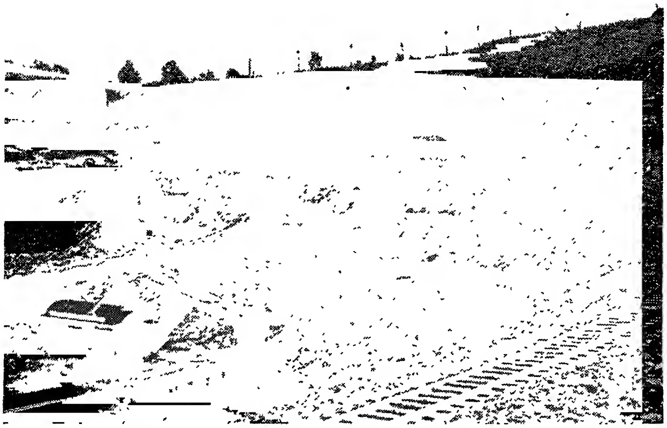
[8] Portland cement is said to derive its name from its resemblance to a rock found on the English isle of Portland.—*Ibid.*

ciate the full importance of having buildings which will last for centuries rather than those which need renewing in a few decades. At the present time we are losing by fire nearly half as many buildings as we erect and the life of past constructions has at best been short. Good concrete buildings are permanent, and enrich the nation by their durability as well as by the saving in other materials. Cement has, in addition, exceptional ease of construction. Building stones must be laboriously shaped, bricks must be slowly laid by hand, but cement is mixed by steam or electric power and poured into molds with an ease that makes it a natural product of machinery and unskilled labor. Standardized forms of wood or metal are now used repeatedly for all types of building construction. Its use for girders, boats, fence posts, and shingles seems to indicate that there is almost no limit to the service cement can render.

The American Cement Industry. Fortunately the raw materials, limestone and clay or limestone and shale, are to be found in every state, and the fuel for burning is also widely scattered so that there is the possibility of having many cement districts as the demand increases. The fact that the manufacture of cement uses about one-third its weight in coal has helped to make the Lehigh Valley in eastern Pennsylvania the leading cement section of the United States. Here the limestone and shale are close together, at the surface, but a few miles removed from the anthracite coal fields and near an abundant supply of good labor from the adjacent Pennsylvania German settlements. This field is less than 100 miles from Philadelphia and New York,



The location of cement plants in the United States. It is doubtful if there is any other industry of equal importance that is so evenly distributed among the people of the United States. Note the cluster in eastern Pennsylvania close to all the raw materials and approximately equal distance from the great home markets and the export ports of New York and Philadelphia.



This quarry at Northampton, Pennsylvania, has produced 100 million tons of rock for cement making. It yields a shale with a fortunate mixture of limestone that makes it unusually satisfactory for making cement, which must have limestone and clay in the form of earth or shale rock.

which are both great markets and also convenient places for shipment by water to places where cement is used in large quantities. In 1941 Pennsylvania was still the leading manufacturer of cement, with nearly one-fifth of the nation's output, but its share of the total naturally continues to decline as production increases in California, New York, Texas, Michigan, Ohio, and other states. Like other earth-building materials, cement tends to be a local industry, and it is now being made in three-fourths of the states of the Union. The average factory price of a 376-pound barrel of cement in 1942 was $1.53. As shipping such a cheap and heavy product very far will more than double the cost to the consumer, it is plain that a local plant has a great advantage over distant plants.

Foreign Cement Industry. Because of the great importance of the natural cement industry in England and the high reputation of its product, it was not until the eighteen-fifties that Portland cement proved its superiority over natural cement, but thereafter the industry expanded rapidly in England and spread into Belgium and Germany. European manufacturers turned out a high quality of Portland cement, shipping large quantities overseas. American imports of European cement increased rapidly between 1878 and 1893, and it was not until 1896 that our domestic production exceeded imports. At the outbreak of World War II, Germany, Great Britain, Russia, Italy, France, and Belgium were the leading producers in Europe. In most years Europe and the United States produce about 80% of the world's cement.[9]

Cement is now manufactured by more than 50 nations and colonial territories, Japan being the leading pro-

[9] In 1938 the production of cement, in millions of metric tons, was as follows: World total—83.8, United States—18.3, Germany—15.6, Great Britain—7.9, Russia—5.7, Japan—5.5, Italy 4.6, France (1937) 4.3, Belgium 2.9.—*Statistical Year-Book of the League of Nations*, 1940/41, Geneva, 1941, p. 158.

ducer outside of Europe and this country. The nations of northwestern Europe continue to be the leading exporters of cement, but many countries have achieved self-sufficiency, and since World War I the world trade in cement has declined.

6. *Pottery and Porcelain*

The making of pottery from clay, first developed by Neolithic man, was a well-established art in the Old World civilizations of Babylonia, Egypt, China, and India, and in the New World civilizations of Maya, Aztec, and Inca. Porcelain, a semi-translucent form of chinaware, has been made in China for well over a thousand years. In many parts of the world, as in the Far East, many sections of Latin America, and among the Indians of our Southwest, the manufacture of pottery remains a handicraft trade, and even in the modern factory a large amount of skilled labor is required. The pottery industry of today includes a wide range of products, such as bathroom and toilet fixtures, hotel and household chinaware, red earthenware, porcelain electrical supplies, and garden and ornamental pottery. In the United States chinaware and sanitary ware comprise about half of the total value of the output of the pottery industry. While our ultramodern bathroom facilities are perhaps not the quintessence of American civilization, they are indeed the envy of the rest of the world.

Modern Methods of Manufacture. Although common clays will often make satisfactory pottery, the finer ceramic wares usually require pure clay such as kaolin, or china clay, which can be heated to 3,000° F. without melting. Other raw materials include quartz to give rigidity to the product, feldspar, which acts as a flux to bind the materials as they fuse, and various glazing materials to impart a glossy finish to the outer surface of pottery. In early times unusual skill was required to mix successive batches of raw materials that would produce exactly the same quality, but in the modern establishment the materials are apportioned, finely ground, and mixed mechanically with scientific precision and then put through a filter press and allowed to season. After the "green" clay is formed into the desired shape,[10] it is burned or fired. Except for the most common ware requiring no gloss, there are two firings, one known as "biscuit" firing to fix the form of the ware and a second known as "glost" firing to vitrify the product after the glaze solution has been applied. This may be done in a stationary kiln, a conical structure in which the clay forms are stacked by hand. A more recent development is the tunnel kiln, about 300 to 500 feet long, through which cars convey the clay forms, the mid-section of the kiln being heated to a temperature high enough to fuse the clay. The tunnel kiln permits continuous operation and, together with the use of belt conveyors and other automatic devices for transferring the green wares from one process to another, has proved a great boon to large-scale production. Note the close resemblance to the assembly line.

[10] Clay may be given the desired shape by pressing, jiggering, or casting.—See Evan B. Alderfer and Herman E. Michl, *op. cit.*, pp. 198-199.

Pottery and Porcelain in Europe. Special porcelain centers have been important since the origin of world commerce. Early in the eighteenth century a German rediscovered the very old Chinese art of porcelain-making. A royal factory was established at Meissen, Saxony, and another at Berlin. Dresden china, however, is probably the most internationally famous of all German porcelain ware. For years prior to World War I, Germany was the world's leading manufacturer of porcelain. Austria and Czechoslovakia also have important porcelain manufactories, the products of which are exported in considerable quantity.

For the last century and a half, France has been Germany's chief rival in the production of fine porcelain, the factory at Sèvres having long been the rival of the German factories at Meissen and Dresden. The town of Limoges has given its name to a fine porcelain ware, much exported to the United States.

Since the fifteenth century, Majolica ware has been exported from Majorca, one of the Balearic Islands, where the industry originated through the influence of the Saracens. Italy has long been known for its export of faience, a soft-finished, highly decorative pottery produced in Faenza.

The pottery industry in England has had an interesting shift in its sources of raw materials. It first began in a large way in a district of Staffordshire, known as the "Potteries," where there was an abundance and variety of clays in close proximity to the coal necessary for burning them. Burslem, one of the pottery towns of England, was the birthplace of Wedgwood, the originator of the ware that bears his name. Upon the introduction of porcelain-making, which requires pure kaolin, mixed with flint and feldspar, it was found necessary to import a clay from southeastern Cornwall and Devonshire. This import of the fine raw material from a distant source did not cause the shifting of the industry, because Staffordshire had an organized industry, the necessary fuel and the coarse clay suitable for the manufacture of saggers, the heavy vessels in which, as temporary casing, the product is fired, and which often require actually more clay than is used for the fine porcelain itself. England is the world's leading exporter of chinaware, the United States, Canada and Australia being her best customers.

Pottery and Porcelain in the United States. While the production of pottery in this country began in early colonial times, it was not until after 1850 that the manufacture of better grades of white ware got under way. For years our pottery industry was concentrated at Trenton, N. J. The supply of raw materials for this city is diverse, like that for the English porcelain industry. The coal comes from eastern or western Pennsylvania, and the local clay suffices for the coarser uses of the industry. Quartz and feldspar are brought from the Adirondacks and the southern highlands of New York, and most domestic kaolin clay comes from Georgia and the Carolinas. Much of the finest clay is imported from England, being brought back very cheaply by vessels which took out thousands of tons of American agricultural products and must otherwise come back well-nigh empty.

A skilled labor supply was always available at Trenton, and in the past this city was one of the best places in

the United States for the manufacture of pottery. While some high-grade chinaware is still produced in Trenton, the city is now famous chiefly for its output of sanitary ware. Many of Trenton's potteries have failed to modernize, and the industry now tends to migrate to the Ohio Valley. In about three generations an early industrial start often winds up in conservative stick-in-a-rut-ism.

For some years New Jersey has been surpassed by Ohio as the leading pottery state, with East Liverpool as the major producing center. At Zanesville and other Ohio and West Virginia towns are scores of potteries utilizing Appalachian coal and both domestic and foreign clays. Although American potteries have turned out some excellent China ware, such as Lenox ware, that has taken prizes at international expositions, our more wealthy citizens prefer the imported product. In this country the emphasis has been on quantity rather than quality, medium and low-priced chinaware reaching the average family over the counters of department stores, five-and-ten cent stores, and through other economical channels of distribution. In the quantity and quality of their sanitary ware, however, American potteries have no peer.

China and Japan. China, so long famed for its porcelain, taught the trade to the Japanese centuries ago, and the pupils now rival their teachers in the excellence of their porcelain. This old Japanese industry has long depended on charcoal from the wooded hills and hammers driven by water wheels to grind the clay and stone. The destruction of forests in the pottery districts has caused the use of coal to be introduced; but fuel is economized by having the ovens placed one above the other upon the sides of steep hills, so that the heat passes from one oven to the next, and is thus made to perform its greatest service. The Japanese porcelain makers, like the other Japanese artisans, were, until a recent date, individual artists, but the quality of their product is declining, because of wholesale manufacturing and the desire to make cheaper goods for the foreign markets. The Japanese porcelain industry is well developed, being third in production, and, in exports, second only to the British.

7. *The Manufacture of Glass*

The Nature and Location of Glass-making. Glass is essentially fused sand very much as pottery is fused clay, for when sand is mixed with soda ash, lime, broken glass, and other ingredients [11] and is heated to a temperature of 2,500° to 3,000° F., it melts to a sticky, non-crystalline mass that cools slowly and can be easily worked into finished products of various shapes. Glass sand must be high in silica and low in iron oxide and alumina if clear glass is to be made, and if the sand particles are small, uniform, and angular, much better fusion

[11] Lime in the form of calcium oxide and carbonate gives hardness and permanency and facilitates melting and refining. Soda ash, or sodium carbonate, which costs five or six times as much as sand, serves as a flux to facilitate the mixing and melting of other ingredients. Scrap or broken glass not only helps to reduce raw material costs but also shortens the melting time, reducing fuel costs. Salt cake, or sodium sulfate, helps to lower the melting point and viscosity of glass, but its use has been declining with the increased adoption of automatic temperature control. Other raw materials include potassium carbonate and nitrate, boric acid, borax, and small amounts of coal, lead, barium, arsenic, and antimony.—See *ibid.*, p. 203.

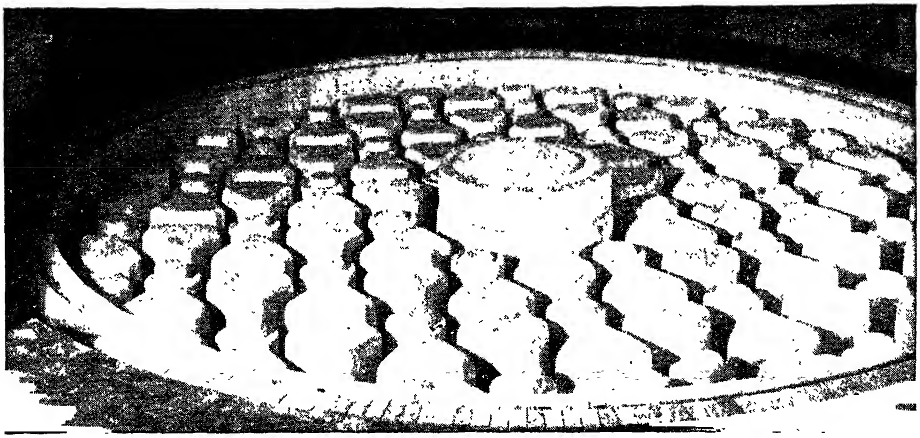
results. Raw materials do not play a dominant role in the location of glass manufacturing. Their cost is only 10% to 15% of the total cost. Glass sand is comparatively abundant and scrap or broken glass may comprise as much as 50% of the material. Proximity to markets, because of the high freight rates on glass, and the availability of fuel, particularly natural and artificial gas, are now the major factors determining the location of the industry.

With modern methods of manufacture, glass can be made that is transparent, translucent, or opaque, brittle or shatterproof, pliable or tough as iron. The day may not be far off when spun glass will compete with natural fibers in the manufacture of textiles and clothing, glass bricks are being used increasingly, and already glass is replacing metals for various uses. At the present time, however, the principal markets for glass are in the manufacture of containers for bottling beverages, foods, medicines, and other products, in making window glass for buildings and automobiles, and in the production of table and kitchen ware.[12]

The American Glass Industry. The United States leads the world in the manufacture of glassware. Like iron, the industry began with a wood-burning epoch, which caused it to be centered in New England and the eastern states. In 1776 a glass company established itself at Glassboro on the sands of south central New Jersey, where a tract of 35,000 acres of woodland growing on sand was secured to produce the fuel. With the depletion of forests, New Jersey glassmakers turned from charcoal to the use of producer gas obtained from coal, and more recently they have shifted to fuel oil which is delivered cheaply by tanker to Delaware River points. For some time Philadelphia and the New Jersey towns of Bridgeton, Salem, Millville, and Glassboro were among the leading glass manufacturing centers in the country, but years ago most of the glass industry migrated westward to be near the Appalachian coal and gas fields. Natural gas and the artificial gas obtained from coal make ideal fuels, for they are easily controlled and produce a high and uniform temperature. The importance of fuel and market factors in determining the location of the industry is revealed by the fact that over half of the nation's glass is produced in Pennsylvania, Ohio, and West Virginia, with Pittsburgh as the leading center. These states are followed in output by Indiana and Illinois, each producing about twice as much glass as New Jersey. In recent years glass manufacturing serving local markets has developed in Oklahoma and Texas, where natural gas is exceptionally cheap. The old New Jersey industry continues to survive largely because of the momentum of an early start, nearness to large urban markets, and growing specialization in laboratory glass and other quality products.

At the present time glass is melted in regenerative furnaces, similar to those used in steel-making, with capacities ranging up to 1,500 tons. Various mechanical devices have been perfected by which the molasses-like molten glass

[12] In 1939 the value of pressed or blown glassware manufactured in the United States was $249,000,000, including containers worth $156,000,000, while the value of flat glass was only $71,000,000.—U. S. Dept. of Commerce, *op. cit.* p. 881.



Into this assembled mold the glass was poured for making the 200-inch disk for the world's largest telescope.

either flows out, is poured out, or is sucked out of the furnace, after which it is ready for shaping, which may be accomplished by rolling, drawing, pressing, casting, or by blowing the viscous material into shape with the use of compressed air. After shaping, it is necessary gradually to cool or anneal the glass, this being carefully done in long tempering ovens known as "lehrs."

For a long time practically the only means of shaping glass was to dip a long tube into the clear pool of liquid glass and blow through the tube, so that, by whirling and blowing, the expanding bubble of molten glass became, upon cooling, the desired vessel—a craft of almost unbelievable skill. For window glass it was blown into cylinders, which were cut open and allowed to fall upon a table to cool. Glass blowing is difficult work, requiring very great skill and commanding high pay. In the manufacture of bottles one of the glass blower's most difficult problems was to dip out of the tank the exact amount of glass needed, an obstacle that was not solved until 1903 when Michael Owens, an Ohio glass blower, invented a rotating wheel with arms equipped with plungers using the suction of compressed air to pull up a definite amount of molten glass. The Owens machine, coupled with the use of conveyor belts and other mechanical devices, can now produce 75,000 bottles a day. As a consequence of mechanization, the average output per man per year in the United States in 1935 was 245,000 containers, as compared with only 40,000 containers at the turn of the century.[13] The manufacture of containers is now the most important branch of American glass-making, accounting for over 40% of the total output of the industry.

In the manufacture of ordinary window glass mechanization has gone so far that the entire output in this country is produced by an automatic, continuous process. One result of automatic production has been a reduction in the number of plants and companies. In

[13] Temporary National Economic Committee, *Hearings*, Part 2, Washington, 1939, p. 755.

1941 there were only 15 plants, as compared with 82 in 1917, more than three-fourths of the nation's output being produced by the Libbey-Owens-Ford Glass Co., the Pittsburgh Plate Glass Co., and the American Window Glass Co., operating plants chiefly in western Pennsylvania, West Virginia, and Ohio.

Plate glass differs from window glass in that it is ground and highly polished. In 1922-23 the Ford Motor Co. and the Pittsburgh Plate Glass Co. developed a new method consisting of continuous drawing, rolling, grinding, and polishing which greatly speeded up production.[14] As the automobile manufacturers in the nineteen-twenties turned more and more to the production of closed cars and as in the following decade they equipped cars with laminated or shatterproof glass, which requires two sheets of glass or double the area of glass per car, the demand for plate glass was greatly stimulated. In recent years about three-fourths of all plate glass in this country has been used by the automobile industry.

The greatest plate-glass center in the world has long been in the Belgian town of Charleroi, and a Pittsburgh glass company has established similar plants for producing the same plate glass at a town named Charleroi near Pittsburgh.

Glass Industry in Foreign Countries. In the coal-rich countries of northwestern Europe are to be found favorable conditions for the manufacture of glass: a large supply of producer gas, cheap skilled labor, and great markets. It is probably true that the glass industry is relatively more important to the Belgians than to any other people. This small country, but little larger than Maryland and with a population one-fifteenth that of the United States, has a glass industry almost one-third as great as this country. It is located along the edge of the coal fields of Liége and Charleroi close to sand quarries and soda factories. This district, which has long been the leading window-glass center of Europe, furnishes Belgium one of her leading exports.

Germany is second to the United States in glass production. As in the Pittsburgh district, the chief centers are located close to the iron districts, being along the Rhine, and near the coal fields of Saxony, and Silesia. This southeastern coal field in Silesia borders the Czechoslovak province of Bohemia, which has long been famous for its colored glass. In the south German states of Bavaria and Saxe-Weimar, special qualities of glass are made for use as lenses. In the little city of Jena, the Zeiss factory, with its highly trained scientific workmen, produces the glass of exceptional fineness, which for many years was to be found in the lenses of the microscope or telescope in

[14] Henry Ford, nettled by the high cost and large breakage of the plate glass part of an automobile, thought it ought to be made more cheaply. He had an idea. He called into consultation all the plate glass experts. They told him his idea was crazy. He paid them their fees and dismissed them. He started a little plant and worked in it a large part of the time for two years, and as a result he cut the cost 80%. He made glass by a system which begins by running a stream of molten glass across a moving platform at the rate of 53 inches a minute. Careful study showed this to be the speed to let the glass cool off at such a rate that it can be pressed, polished, cut into lengths without ever stopping its movement. As a result this continuous stream of plate glass flows night and day and the machinery stops only when it is to be replaced after being worn out. Henry Ford is a (mechanical) genius. Although the Ford Motor Company is equipped to make a large part of its requirements, it has purchased most of its glass since 1931.

almost every observatory and laboratory throughout the civilized world.[15]

The French glass industry is located near the northern coal fields along the Belgian frontier where the town of Baccarat is the center of the manufacture of French crystal glass. In England the best glass sands are found along the south coast of England near Hastings and on the Isle of Wight; but the chief centers of glass manufacture are upon the three coal fields near Birmingham, Bristol, and Newcastle. There is also much manufacturing in London, where the factories have exceptional facilities for easy delivery of the brittle product to the vast market in the metropolitan area, and to ships in the harbor.

Glass resembles pottery in the abundance of its uses, and it presents even greater difficulties of transport, but the heat is too great to make it in the tropics, the high heat and suitable fuel are much more difficult to secure than for pottery, so it is not so widely distributed. While pottery has long been made among primitive peoples, the manufacture of glass is heavily concentrated among the more advanced industrial nations. Most countries with undeveloped manufactures and practically all the colonial territories are importing their glass from Germany, England, Belgium, Czechoslovakia, and, to a lesser extent, from the United States.

The United States imports some European glass, especially the finest grades for lenses and for scientific work. However, since World War I, and especially during World War II, great progress has been made in this country in the manufacture of glass for optical and scientific uses, with important centers at Rochester and Corning, N. Y. We also export considerable quantities of our machine-made glassware. Machines have replaced hand labor and skill in virtually all of the cheaper glass.

[15] The origin of this glass—the joint work of Professor Abbe (mathematician) of Jena and Carl Zeiss, a local glassmaker and optician—is another good example of the influence of German university science on industry.

. . . 10

The Metal-Fabricating Industries

1. Factors of Location

The manufacture of iron and steel, copper, aluminum, and other metals does not end with the production of ingots, bars, billets, blooms, plates, slabs, sheets, tubes, rods, and wire. While many of these primary products are converted into finished manufactures by the great metal-producing companies and their subsidiaries, large quantities of metal in crude form are sold each year to other important industries for fabrication, as to the machine tool, agricultural implement, and automobile-manufacturing industries. The location of each of the great metal-fabricating industries is the result of certain definite factors. Machinery is used in every continent and in every country, but practically all of it is made in restricted sections of a few countries.

Shipbuilding must be done where the ships can be launched, but the location of other classes of machine building is influenced by two factors which often tend to conflict but which frequently coincide—labor and the market. Machinery of all kinds is made primarily of metal, mostly iron and steel, and secondarily, of copper, aluminum, and wood. It is easy to see how a carload of metal or wood is much less bulky than the same materials made up into machinery. It is therefore a transportation advantage to have the factories located near the market rather than near the raw material. On the labor side it is true that the market is often in a distant region of small purchases and high wages so that there is an advantage in labor cost if the machinery is made where the labor supply is abundant, the wages low, and a large product can be marketed. In some classes of machinery, such as agricultural machinery, the transportation cost is heavy in proportion to the weight, and the dominating influence of the market is strong, tending to locate the industry. In other classes of machinery such as clocks and watches the freight element in the cost to the ultimate consumer is relatively small and the labor element is large, with the result that the labor element has strong influence in the location of the industry. Switzerland is the best-known watchmaker. In this country, Waterbury, Conn., and Waltham, Mass., have maintained their watch and clock factories in the East, where, for decades, their workmen have been trained. Another important difference to be observed among the different classes of machinery is the narrowness or wideness of the area of consumption. In this respect equipment machinery of the class used in textile or sugar factories is much more restricted than clocks, firearms, or vehicles which are for general consumption rather than for equipment of restricted industries.

The manufacture of machinery for factories is nearly always a sort of sec-

ond stage in industry, the first stage being the growth of the industry which uses the machinery, thus developing the market for it. Heavy machine manufacture tends to develop near each particular industry using that machinery. Philadelphia and Worcester, Mass., make textile machinery and Denver heavy mining machinery. California makes peach canning machinery, while cotton gins are made in Southern cities. The order of development is somewhat as follows, as shown, for example, by Russia—first agriculture, then after importing agricultural machinery for a time its manufacture begins, but in factories equipped with machinery from countries more advanced in manufacture. The manufacturing of machinery to make machinery is a yet more mature stage of industry.

With world commerce the use of machinery is spreading into the remote corners of the world, hence a rapidly increasing export from the manufacturing countries. It takes much thought to realize how fully this is an age of machinery.

2. *Machinery for Manufacturing*

Location Factors. The manufacture of machinery for manufacturing tends to occur near to the place where used. This industry is a kind of parasite, a hanger-on, or a purveyor to other manufacturing industries. Aside from the advantages of freights and transportation, there is a great convenience resulting from the ease in making repairs and replacements when the machine-producing factory is near the machine-using factory. There is yet another reason. Improvements in machines are most likely to be conceived by people who use and repair them and watch them while they work.

Textiles, our oldest modern industry, give ample illustration of these factors in the location of their machine supply industry. The bulk of the English textile machinery is made in Manchester, Bolton, Oldham, Accrington, and Rochdale, all of them in the Lancashire district. As this district has led the world in making cloth, so it has led the world in the export of textile machinery, in which Britain far exceeds all other countries together. The distribution of British exports of textile machinery is almost a record of the geographic distribution of the textile industry.

In this country well over half of all textile machinery is manufactured in New England, which only since 1924 has been surpassed by the South as the greatest producer of cotton textiles and which still leads in the manufacture of woolens and worsteds. Textile machinery made in Worcester, Lowell, Hyde Park, Whitinsville, Mass., and other New England towns has long been used locally and throughout the nation.[1] Philadelphia, a great textile center, is also an important producer of textile machinery.

Importance of Metal-working Machinery (Machine Tools). The machine tool is a power-driven machine that is

[1] Massachusetts accounts for about 40% of the total value of all textile machinery made in the United States. In the manufacture of shoe machinery, Missouri, with a great and growing shoe industry at St. Louis, ranks first and is followed by Massachusetts, the leading shoe manufacturing state. Ohio, with its huge rubber manufacturing industry at Akron, is the foremost producer of rubber machinery. Alabama, Texas, and Georgia are the major producers of cotton gins.

used to cut or shape metal,[2] and it is indeed the keystone of machinery manufacture. Without machine tools, the large-scale production of modern machinery, including machines that make machines, would be utterly impossible. While machine tools vary greatly in form, size, and use, in general it may be said that they perform five basic functions—milling, planing, turning, boring, and grinding. Each of these operations has long been accomplished by hand or by very simple mechanical aids.[3] For each of the five basic metalworking operations large, heavy, expensive but exceedingly efficient machines have been devised.

The first milling machine in this country was devised about 1818 by Eli Whitney, famed inventor of the cotton gin, for making the first interchangeable parts used in guns, which were sold to the United States Government.[4] The modern power-driven milling machine consists of a rotary cutter with multiple cutting edges and operates much like a circular saw. A modification of the milling machine is the hobbing machine for cutting gear teeth. Planing machines will, when once set and started, work for hours smoothing one side of a piece of metal as big as the floor of one or two small rooms. Turning consists of shaping a rotating piece of metal into cylindrical or other curved surfaces with an ordinary lathe, the oldest of all machine tools.[5] The modern turret lathe is so designed that the operator can bring a succession of different cutting edges to the work over and over again, one at a time, to perform the various operations required and thereby turn out almost any shape that a pattern may prescribe. A turret lathe can usually turn, bore, and shape at the same time. Boring or drilling is done by single or multiple spindle machines that cut, enlarge, or finish a round hole with a rotating cutting tool, and some machines can drill more than 100 holes at one time. Grinding consists of shaping a piece of metal by bringing it into contact with a rotating abrasive wheel, and it includes such finishing processes as polishing, buffing, and lapping. While a lathe can turn out work that is true to within one sixty-fourth of an inch, the precision grinder will grind either round or straight within limits of two ten-thousandths of an inch. Sometimes two or more basic operations are performed at the same time, as is the case of turret lathes, combination milling and planing machines, and combination milling and boring machines.

Most of these machine tools have been improved to the point where they become automatic. This condition is attained when a machine will take pieces of material and turn out a uniform product. Thus, a roll of wire is fed into one end of a machine, and finished wire

[2] The National Machine Tool Builders' Association defines a machine tool as "a power-driven complete metalworking machine not portable by hand, having one or more tool or work-holding devices and used for progressively removing metal in the form of chips."—John G. Glover and William B. Cornell (ed.), *The Development of American Industries,* Prentice-Hall, Inc., New York, 1941, p. 557.

[3] In woodworking, the carpenter uses the chisel, plane, saw and lathe, brace and bit, sandpaper and stone to perform these functions, all of which have been mechanized in large woodworking establishments.

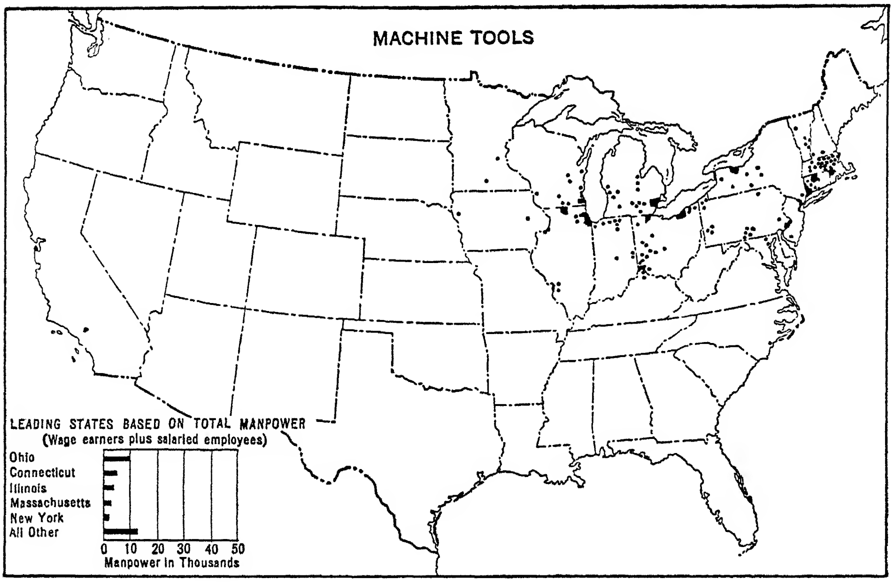
[4] *Cf. ibid.,* pp. 564-565, and Evan B. Alderfer and Herman E. Michl, *Economics of American Industry,* McGraw-Hill Book Co., Inc., New York, 1942, p. 113.

[5] It was the perfection of the engine lathe that made possible the large-scale production of steam engines.

This big hemisphere of metal is the head of an engine boiler. It revolves against the cutting instrument to the right, which is smoothing the exterior of the hemisphere. This machining of a curved surface is similar in fundamentals to the driving of a big piece of metal against a cutting instrument to smooth a flat surface, or cut notches, which become the cogs of a wheel—typical of metal cutting that almost might be called the main work of machine manufacture.

nails come out at the other. A roll of brass or steel wire is converted into screws, and each of the necessary processes is done by a machine that takes the blanks by the bushel and works them up into a finished article of remarkable cheapness. Again, a rod will be cut into a series of perfect bolts, nuts, or screws of exact dimensions and each just like all the rest. That likeness is the great economic secret of this mechanical age. These mechanical means produce the many parts which, upon being put together, make the complex, efficient machines of the modern factory.

The Manufacture of Machine Tools. The machine shop is the market for machine tools, and the machine shop is located where machinery is to be made or repaired. It is plain that repair shops, even more than plants for new construction, must cling to the places where machinery is used. The machine-tool industry is therefore located by the machine users, and interesting responses of location result. It is an industry without any great center, but in seeking its market it tends to concentrate in regions of important manufacture (see Fig. 263). Thus the Lower Lake Region with its natural resources for the manufacture of automobiles, agricultural implements and other metal products, has become one of the recognized centers for machine-tool manufacture. Cincinnati, Detroit, Chicago, and Cleveland are among the leaders, while Dayton, Toledo, Indianapolis, and Milwaukee are also important, the Middle West now being the leading machine-tool manufacturing region. In the East, Philadelphia is a center for this line of manufacturing,



The location of machine tool manufacturing in the United States shows that this is a mature industry. Note its complete absence in the South and in many western states.

because of the need of her textile mills, her engine factories, her locomotive works, and the shipyards of Camden, Chester, and Wilmington upon the Delaware. Buffalo and Rochester have also developed an important manufacture of machine tools.

As New England was the birthplace of the Industrial Revolution in America, so it was the cradle of the machine-tool industry. Manufacturers of firearms in such towns as Hartford, Conn., and Providence, R. I., were the first to produce smaller precision machinery, while builders of textile machines and engines in Lowell, New Bedford, and Worcester, Mass., Manchester and Nashua, N. H., and other textile centers began the production of heavier types of machine tools.[6] New England has long been endowed with a high type of skilled labor, which is of vital importance in the machine-tool industry, and this region still produces well over a third of the total value of all machine tools made in the United States. It is almost impossible to appreciate how definitely the machine tool, maker of other machines, is at the very base of this modern economic society. It is a good exercise to enumerate its services.

Engines and Motors. Engines or electric motors are used in almost all kinds of factories, and also in nearly all mines and on many farms. Their market is not quite so restricted as that for machine tools, but their manufacture is located by the same factors and is distributed in the United States from Lake Michigan to the Atlantic and southward to southern Pennsylvania. Some of the heaviest engines in the United

[6] See John G. Glover and William B. Cornell (ed.), *op. cit.*, pp. 563-564.

States are made at Milwaukee, Wis., which is conveniently located to distribute them by boat to all manufacturing cities on the Great Lakes and by rail to the North Central States and the mining regions of the Rocky Mountains. Further east, Pittsburgh with its huge iron and steel plants, requiring so much heavy machinery, is an important center for the manufacture of heavy engines and electrical machinery. Philadelphia, New York and environs, and southern New England have other important engine manufactures. At Schenectady, New York, on the main line of railway from Boston and New York to the West is one of the greatest electrical manufacturing plants in the world.

In the manufacture of engines, Germany was the leader on the scientific side. In the past, science has been respected more and taught more there than in any other country, and new types of engines are primarily the result of a great amount of scientific study and experiment. Another force driving to this result is the German scarcity of petroleum, a fact which places a premium on economical power generators. One of the most significant of the German inventions is that of the Diesel engine, which burns low-grade fuel oil as automobiles do gasoline. In recent decades Sweden has developed an important manufacture of marine engines, electric motors, and many types of machine tools, and Great Britain, of course, has long been a leader in the production of all kinds of machinery. The United States, however, is not only the world's greatest producer but also the greatest exporter of machinery (see Table 18).

TABLE 18

Machinery Exports of the Leading Countries

(In millions)

	1910 *	*1920* *	*1923* †	*1939* ‡
Great Britain	$142.0	$232.1	$203.4	$263.3
Germany	119.0	112.5	125.2	251.0
United States	110.0	536.3	260.6	502.1
France	20.0	37.0	49.9	27.6
Belgium	12.0	17.1	16.1	29.4
Switzerland	14.0	47.5	27.3	51.8
Netherlands	6.0	10.6	9.5	41.0
Sweden	.....	31.7	29.3	58.0
Canada	.....	14.6	15.9	20.0
All other	43.0	40.6	37.8	85.6
Total	$466.0	$1,080.0	$775.0	$1,329.8

* From Chart in The Philadelphia Commercial Museum.
† From *Commercial America*, July, 1924, page 15.
‡ *Foreign Commerce Yearbook.* These figures merit careful study.

3. The Manufacture of Agricultural Machinery

The Origin of Agricultural Machinery. Throughout most of the nineteenth century large areas of cheap land in combination with the consequent high wages dominated industrial conditions in the United States and made it impossible for the farmers, under the old system of hand labor and simple devices, to cultivate as much ground as they could easily secure. Necessity has in this form been the mother of the invention of agricultural machinery, which has been perfected to a greater degree in this country than in Europe. The period from 1830 to 1860 witnessed the invention and improvement of many agricultural implements, such as the steel plow, grain drill, reaper, thresher, mowing machine, hay rake, and corn cultivator, all of these being operated by horse power.[7] These inventions, and many another, greatly reduced human toil in farming, enabling a farmer to cultivate more land and reducing his costs per unit of product. The new machinery was especially well adapted to the vast expanse of level prairie in the Middle West, an area that could well use labor-saving devices, which proved to be a powerful force contributing to the westward migration of American agriculture. These inventions and the great demand for the machinery have given rise to an important manufacturing industry, and the excellence of the product has led to a large and growing export to the agricultural countries of the world. The thoroughness of our invention and the scope of our agricultural machine works are shown by the virtual absence of imports of machinery of this class, while we have exports far greater than any other country.

The Service Rendered by Agricultural Machinery. In 1850 we produced 1 ton of cereals per person. In 1900 with a smaller proportion of the population engaged in agriculture, we produced 1½ tons of cereals per person. This increase in the efficiency of the producer of breadstuffs is due largely to the machinery he has used. The inventors and manufacturers of agricultural machines have produced many devices to do each important agricultural process. Thus agricultural machinery has replaced hand labor in production as the locomotive and the motor truck replaced the wagon in transportation, and the two classes of machinery together have given the world cheaper food and raw materials than it ever had before.

It would be a great error to think that this process of machine improving has ended or that its results are all in sight. The census of 1940 showed astonishing changes due to agricultural machinery. Within 40 years the rural population

[7] Each of these machines was the result of long experimentation and improvement, many minds contributing to their ultimate success. Thus, many reapers were invented, but those of Cyrus Hall McCormick and Obed Hussey proved to be the most practical. Hussey invented his reaper on a farm near Cincinnati, patented it in 1833, and began manufacture at Hagerstown and Baltimore, Md.; and other towns in the East. McCormick invented his reaper on a farm near Lexington, Va., in 1831, patented it in 1834, and manufactured a few reapers in Virginia, but he was shrewd enough to see that the great potential market lay in the Middle West, so in 1845 he contracted for their manufacture in Cincinnati, Ohio, and Brockport, N. Y. (on the Erie Canal), and in 1847 he established his own factory in Chicago.—For an interesting account of the life history of McCormick and the competition among rival reapers, see William T. Hutchinson, *Cyrus Hall McCormick*, 2 vols., The Century Co., New York, 1930 and 1935.

of Ohio, Indiana, Illinois, and Iowa had declined 27.9%. This was almost entirely due to the use of machinery, which between 1900 and 1940 increased by 449.5% in value per farm. This fundamental change was accompanied by an increase in agricultural production and an increase of 11.3 acres in the average size of farms. One should not confuse the average size with the size of the typical farm of the region. It is growing rapidly.

Agricultural machinery has probably made swifter technical advances in the last decade than in any other, as evidenced by the wide use of pick-up baler that bales hay in the field, the combine in the hilly eastern fields, the silo filler that chops corn and hoists it into a 50-foot silo, the farm-all tractor that lets one man make 100 acres of Iowa corn, and a host of new tillage devices. These last are in themselves revolutionary.

A tractor-drawn multiple seeder plants five rows of spinach eleven inches apart, and in beds that are bounded by the tractor tracks. This machine changes, next, to a cultivator that cultivates these five rows of spinach. The crop covers the ground entirely, and is *larger than even hoe tillage could make*. So-called intensive hand agriculture is on the way out.

Taken all together, the new machines threaten to do to agriculture what factory machines did to the cottage artisan. When we see one farm management company in a midwestern city managing 300 farms for absentees, we may say that the revolution is under way.

The rubber tire on tractor, manure spreader, hay baler, etc., has opened a new era in farm machinery.

Location of Manufacture Near the Market. Agricultural machinery is very bulky; freight rates are therefore high, giving a great advantage to the factory located as near as possible to the place where it will be used. Therefore, this industry has always kept close to the edge of the great farming region, especially the grain belt, and it should be recalled that as late as 1839 about half of the nation's wheat was produced east of the Allegheny Mts., New York, Pennsylvania, Virginia, and Ohio being the leading wheat-growing states. For a time the leading manufacture was near the city of Auburn in central New York where the Erie Canal gave easy transportation to both east and west, and in 1830 Pittsburgh led the nation in the manufacture of plows, its product being easily distributed to the markets of the South and Middle West by boats and barges that traversed the vast Ohio and Mississippi river systems. The manufacture of farm implements followed the westward movement of agriculture. The first great centers beyond the Alleghenies were Columbus and Springfield, Ohio, on the edge of the vast level plain of the Corn Belt, which has been the compelling force to make men use farm machinery. In 1860 the Middle West produced about half of the nation's total output of farm machinery, Ohio and Illinois being the leading states.[8] With the further westward

[8] While New England retained leadership in the production of small implements that could be easily shipped to market, such as spades, hoes, rakes, and forks, in 1860 Stark County, Ohio, was the leading manufacturer of harvesters and threshers with an output worth about $1,000,000 and was followed by Cook County, Illinois, with an output worth more than $500,000.—Victor S. Clark and associates, *History of Manufactures in the United States*, vol. 1, McGraw-Hill Book Co., Inc., New York, 1929, pp. 478-479.

movement of the market, the industry centered in and around Chicago, the greatest agricultural market in the world, the greatest railway center in the world, with easy access to the greatest corn, oats, hay, and wheat producing regions in North America. Here are the best facilities in the United States for reaching agricultural districts, and here the great harvester companies located their largest plants. By 1890 Illinois surpassed Ohio in the manufacture of agricultural implements,[9] and it has maintained leadership in the industry until the present day, the value of its output in recent years amounting to over half of the nation's production and more than twice that of Wisconsin, its closest rival.

For decades huge farm implement factories have operated at Chicago, Ill., Racine and Milwaukee, Wis., and South Bend, Ind. In the last century and early years of the present century these plants obtained wood from the splendid forests of Michigan, Wisconsin, and Minnesota, but with the depletion of these forests they were forced to turn to the South for their wood supply, some of the larger firms owning tracts of forest land. Iron, of course, was easily transported by lake vessels from the head of Lake Superior. Other farm implement manufacturing centers developed within the Corn Belt at such points as Richmond, Ind., and Peoria, Ill. The westward migration of the industry is also shown by the development of important manufacturing on the banks of the Mississippi in a cluster of towns including Moline, East Moline, and Rock Island, Ill., and Davenport, Iowa, in the heart of the Corn Belt, and also at Minneapolis, Minn., near the edge of the Spring Wheat Belt. Thus, for well over a hundred years the "pull of the market" has been the dominant factor in the location of the industry. Our growing export trade has not led to the manufacture of this machinery in seaports convenient to the place of shipment, nor is there any apparent prospect. The export is a by-product of the huge home industry, our total production of agricultural implements being worth $746,000,000 in 1941.

Interchangeable Parts. The manufacturing of agricultural implements has received a great impetus from the practice of making machines with interchangeable parts, so that one machine in the factory turns out one piece which will fit any one of the thousands of a given kind of completed machine in the field. Before this practice was established, a breakdown in the field meant that the machine had to be taken to some nearby expert mechanic to be repaired. With interchangeable parts, the owner of the broken machine can get quick repairs, by ordering a new piece by catalogue number from some nearby warehouse—an ability which has made possible the easy use and prompt repair of Chicago reapers, Racine threshers, and Moline plows in the wheat fields of Argentina or Australia, thus greatly stimulating our foreign trade. Extensive warehouses for the prompt supply of parts are maintained by the American "Harvester Trust" in Buenos Aires and many foreign ports.

The interchangeable part, by emancipating the user from the limitations that follow distance from the factory, has enabled the American manufacturer to

[9] *Ibid.*, vol. 2, p. 185.

reap the advantage of the adjustment of his product to the world environment. American agricultural machinery has, as the result of numerous inventions and specializations, been made to fit the great variety of conditions existing in the United States, and for this reason it also suits almost any other country. However, each kind of land and farming has its own peculiarities, and American exporters of farm machinery have learned long ago that it pays to adapt their products to meet the requirements of foreign markets. Thus, one big company especially adapted its mowing machine to cut as close as a pair of barber's clippers for use in Holland, where the grass is short and thick; it designed a light-weight machine for use in Switzerland and southern Germany where a dairy cow must serve at times as a draft animal; and it constructed other machines that could be pulled by oxen, camels, and reindeer in localities where those animals are used as beasts of burden. For England, where it is almost sacrilegious to tear down or alter a wall hallowed by centuries of use, machines had to be designed that could be tilted in order to pass through narrow gates. Machines of the so-called "stump jump" types have been sent to the newly cleared Australian "Bush."

In contrast to American adjustment to special needs, the English have long prided themselves on the substantial character of their manufacture. Much of the American agricultural machinery is lighter in weight, less durable, but less expensive, and for these reasons it appeals strongly to the frontier bonanza grain farmer with his limited capital, whether he be on the plains of the United States, Canada, Argentina, or Australia, in which countries our machinery is much used. The use of the belt-line assembly and other large-scale production methods has made low costs and high wages possible in our factories and has enabled us to sell our machinery profitably at a comparatively low price throughout the low-wage countries of Europe. Canada is our leading foreign market for farm machinery, with purchases amounting to more than $75,000,000 annually, while Great Britain, once our chief rival in production and export, is now our second largest market, buying about $11,000,000 worth of machinery a year.

The Wagon Industry. The making of wagons has an economic kinship with that of farm implements. The truck has almost reduced it to staying on the farm. The wagon resembles other farm machinery in that wood and iron are the raw materials in both; both are relatively bulky when completed, and, therefore, need to be made near the market, which is located primarily in the same region. Almost every farmer must have one or more wagons. The fitness of the North Central states for leadership in both industries is therefore explained.

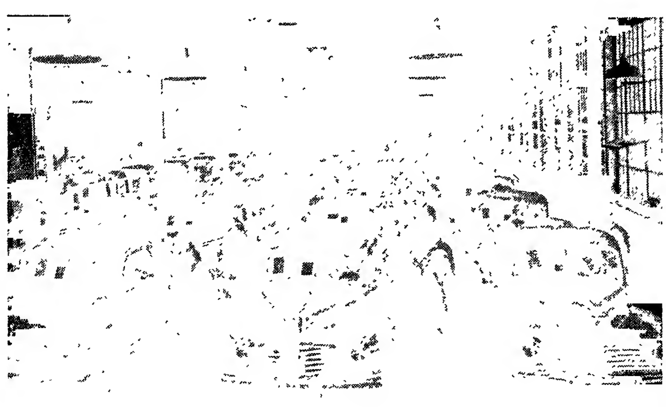
The deciduous trees or hard woods furnish nearly all our wagon woods. Second-growth hickory, which was picked out by Peary to make the sledges for his dash over the Arctic ice fields towards the North Pole, is one of the monopolies of the United States. This wood, unrivaled for strength combined with elasticity, grows from New York to Georgia and Missouri, and is used for making the spokes and hubs of wagon wheels.

The manufacture of wagons has gone through the process of concentration similar to that which has occurred in the shoe and textile industries. Three generations ago the country blacksmith and wheelwright had their shops side by side. One did the woodwork and the other the ironwork, and they manufactured wagons for their neighbors, while the shoemaker next door made the shoes and the tanner at the foot of the mountain made their leather. As shoe machinery has replaced the shoemaker, so automatic woodworking machinery has displaced the country wagon-makers whose hand-made product can no longer compete with the cheaper product of the factories in the North Central states, which send their output to every state and country in the Union, and, in limited amounts, to foreign countries.

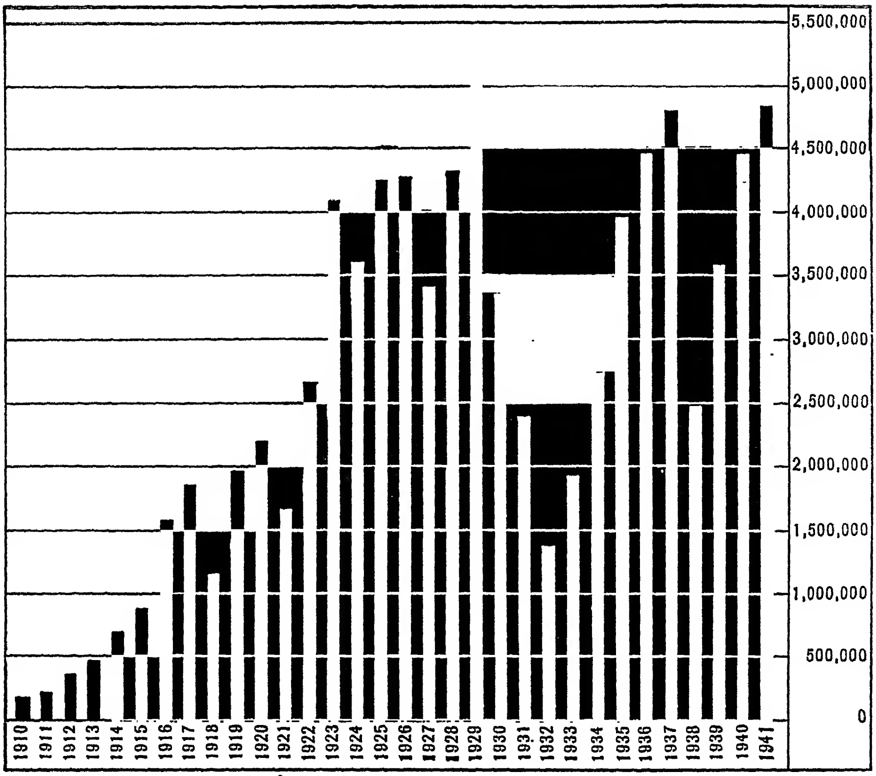
Finally, it should be noted that the ubiquitous motor truck is being used increasingly for work in the fields as well as for hauling produce to market, for it can make many more trips in a day than the horse-drawn wagon. Hence, the motor truck looms as a competitor of the wagon just as the modern tractor has displaced millions of horses and mules in the task of pulling farm machinery.

4. *The Automobile Industry*

The automobile, although only fifty years old, has already assumed vast, almost revolutionary proportions in the social and industrial life of America. What steam did for long distance transportation during its first 100 years of development upon sea and land, the internal combustion motor has already equaled and in some respects excelled in five decades of development for short distance transportation. It has been estimated that the motor cars on the highways of this country now carry yearly at least ten times as many passengers as do all of our railroads. From an expensive plaything and a luxury for the wealthy, the motor car has now become an everyday conveyance for everyday working people, especially in rural



The assembly line. Typical of so much manufacturing, it is probably best known in connection with the automobile, where it first reached its highest development.



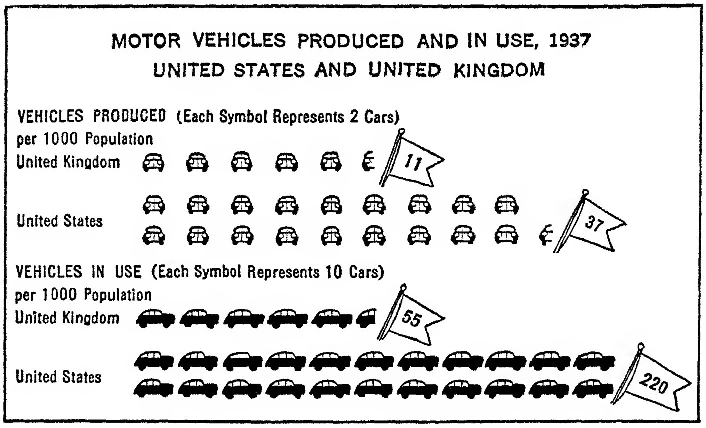
Production of motor vehicles in the United States, 1910-1941. Compare 1929, the year of boom with the year 1932, the depth of the depression, and you have a measure of the need for regularization of economic activity. 1938 shows the result of the United States trying to balance the budget by expenditure. It should be known that national income is really national expenditure. The two are one and the same thing.

America, where its use has made living conditions easier and more pleasant for millions of farmers and artisans. The automobile has now become thoroughly interwoven with the fabric of American life and activity and has eclipsed all previous records for a sweeping change in a people's mode of living.[10]

Swift Development of a New Invention. The first automobiles were made in Europe,[11] and it was not until 1892-94 that the first successful gasoline-driven

[10] The motor car has increased the radius of suburban residential territory near our large cities. Ten to thirty miles to work is not a difficult drive, and it is possible for the city worker to live in a nearby village, or have a country home with an acre or so of ground on a convenient highway. This has greatly extended the radius of suburban land values.

[11] In 1865 Siegfried Marcus produced a gasoline-driven carriage in Austria. In 1876 Nathan Otto of Germany developed an engine that compressed the gas before ignition, vastly increasing the propulsive power. In 1885 Carl Benz mounted an internal combustion engine in a crude frame and drove it through the streets of Mannheim, Germany, and in the following year Daimler mounted an engine in a four-wheeled carriage. Emile Levassor of France conceived the idea of building a chassis suitable for the engine, and in 1892 the firm of Panhard & Levassor issued the first automobile catalogue for a standardized car.—See John G. Glover and William B. Cornell (ed.), *op. cit.*, p. 682, and Lawrence H. Seltzer, "The Automobile Industry," *Encyclopaedia of the Social Sciences*, vol. 2, The Macmillan Co., New York, 1930, p. 322.



The lettering on this graph tells the tale of the comparative wealth of two nations—the one rich in natural resources and larger in scale of industry, and not cursed by an early start, which leaves its legacy of antiquated equipment and method.

motor vehicles were made in this country by Charles E. Duryea, Henry Ford, Ransom E. Olds, Elwood Haynes, and the Apperson Brothers.[12] The early automobiles were rude adaptations of high-wheeled carriages, into which a one-cylinder gasoline engine was installed. They usually gave more trouble than service. It was years before the standard four-cylinder engine of today became practical, as in the early models one cylinder could stall all the others. Gradually American engineers improved the motor, the transmission, the chassis, the body, until the automobile became easy to operate, reliable enough to be used day by day by the ordinary individual, and cheap enough to be purchased and driven by even the workingman and the farmhand. Since 1908 cheap and medium-priced cars have been made and sold in such enormous numbers in the United States that by January 1, 1941, there was one for about every four people. Great Britain, the second largest automotive manufacturer had one for each 26 inhabitants, while in Germany only one person out of 80 owned an automobile. The Germans had been making vehicles for the blitzkrieg instead of the joy ride, and in them they rode to doom and carried many others.

Out of a total of 47 million motor vehicles registered in the world, in 1940, the United States had nearly 32 millions.

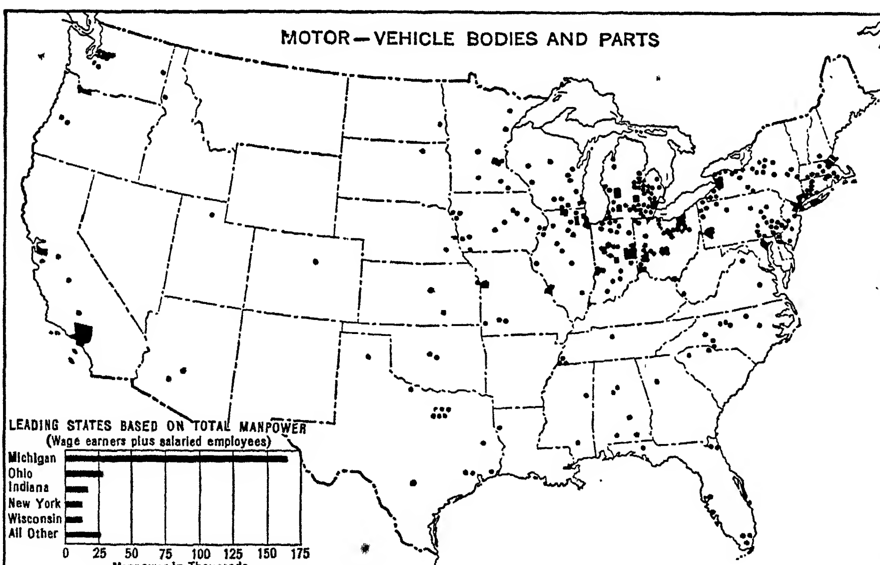
The speed of the arrival of this industry is illustrated by these two facts. In March, 1905, the *New York Tribune* reported that the appearance of two automobiles on Riverside Drive, New York, had made much commotion by scaring horses, and gave the names of persons injured in resulting runaways.

[12] In 1879 George B. Selden of Rochester, N. Y., applied for the first American patent on an internal combustion hydrocarbon motor vehicle. As late as 1900 it seemed that steam would be the ultimate form of power used for motor vehicles, for in that year 1,681 steam-driven motor vehicles were built, as compared with 1,575 electric cars using storage batteries and only 936 gasoline-driven cars. Yet, by 1911 the Stanley steamer was the only steam-driven car that remained in production.—John G. Glover and William B Cornell (ed.), *op. cit.*, p. 684.

Almost forty years later there were 963,465 motor vehicles registered in New York City, and if there had been room for them there might have been other hundreds of thousands. New York City is about the last place in the civilized world to have or enjoy a motor car. It was not planned for motor cars if it can be said to have been planned at all. In contrast, a city like Vienna, with its nearly two million population, had 11,800 private automobiles. The common use of the automobile in the United States today reveals not only the high purchasing power of the American people but also their need for a mobile unit of transport in a land where excessive space has long been an economic handicap.

Location of the Industry. In the strictest sense, motor-car manufacture is not a new industry but rather a successor to the American carriage industry. It was a natural development for the large carriage makers of the Middle West to take up the manufacture of this new kind of vehicle, propelled by a new kind of horsepower, and some of our present-day automobile factories are a continuation of well-known carriage and wagon factories. The rapidity with which the motor superseded the horse for driving purposes is evidenced by the fact that in 1904 the United States produced nearly one million carriages and 23,000 automobiles, but in 1941 the carriage output had virtually ceased, while we were making nearly 5 million motor vehicles.

The Lower Lake Region, with its cheap water transportation and its supplies of heavy metal and wood, is a natural place for this industry. In addition to ore vessels, coal barges and lumber



This map shows a wide distribution of the manufacture of parts for automobiles, but the graph in the lower corner gives the regional weights. This scattering of the manufacture of parts is highly desirable from a national standpoint.

vessels, it has also the best of railway transportation, for it is threaded by the various lines connecting Chicago with Philadelphia, New York, Boston, Montreal and other large eastern cities. This region is also close to the population center of the North American continent, an accidental factor of vital import.

In this natural manufacturing area, the early dependence of the automobile industry upon other factories and machine shops gave it a strong tendency to build up recognized city centers where metal working predominated. In the automobile area, which includes among others Cleveland, Toledo and Akron, Ohio, Indianapolis, and Chicago, the city of Detroit, strategically located on the water route between the Upper and Lower Lakes, has become the recognized leader. In spite of the favorable location, it was probably an accident that made Detroit the center, rather than Toledo or Cleveland or some other city—the accident of having the Ford factory, where the principle of cheap mass production was first applied to the motor car. Detroit has become a busy hive of metalworkers, with over 57% of her products in 1939 coming from some form of metal manufacture, of which three-fourths was from the automobile industry. Motor cars and the allied metal industries in the first four decades of this century have caused Detroit to increase its population sixfold; Lansing, more than fourfold; Pontiac, ninefold; Flint, more than elevenfold, and scores of other Michigan towns have shared this growth.[13] No other industry has a national field for its distribution that is quite so extensive or uniform as that of the motor car. It promises on the average an enduring prosperity to its workers.

American Large-scale Production Methods. While this country produces some of the finest and most costly of motor cars, its greatest achievement has been in standardization and mass production, with its resulting low prices. The early cars were built individually, each part ground and tooled to fit its particular fellow. Then, by the extensive use of automatic machinery, American factories began to make standard wheels, axles, bolts, nuts, bodies, and engines, all so alike that any part would fit any other. Today the manufacture of an automobile involves three major steps in production: designing and engineering, machining, and assembly. About a year before a new model appears on the market, approximately 30,000 man-hours of work are required to design a car,[14] which involves the drawing of many blueprints and the construction of miniature models out of clay and wood, after which the engineers are able to write detailed specifications for all component parts. Then follows the important task of building and installing many special-purpose machine tools to be used in manufacturing the various parts of a car.[15] Approximately 15,000 parts are used in the manufacture of a modern automobile, and these are either shipped to distant as-

[13] The effect of the siren call of automobile factory wages is shown by the increase in Michigan's urban population from 39% of the total in 1900 to 68% in 1940.

[14] Evan B. Alderfer and Herman E. Michl, *op. cit.*, p. 149.

[15] When the Ford Motor Co. finally discontinued production of its Model-T car in 1927, about 70% of all machinery had to be altered or replaced, and fully 18 months elapsed before the plant was able to operate again at full capacity.—*Ibid.*, p. 147.

sembly plants[16] or are carried by beltline or overhead conveyors to points within the automobile factory to be combined into nine primary units, including the frame, motor, body, dashboard and steering wheel, gas tank, wheels, and front and rear axles.[17] These primary units are conveyed to the main assembly line, which is a moving platform about 18 inches high that moves forward at a speed of about 18 feet per minute between rows of workmen, each man continuously repeating his small part of the speedy and endless performance.

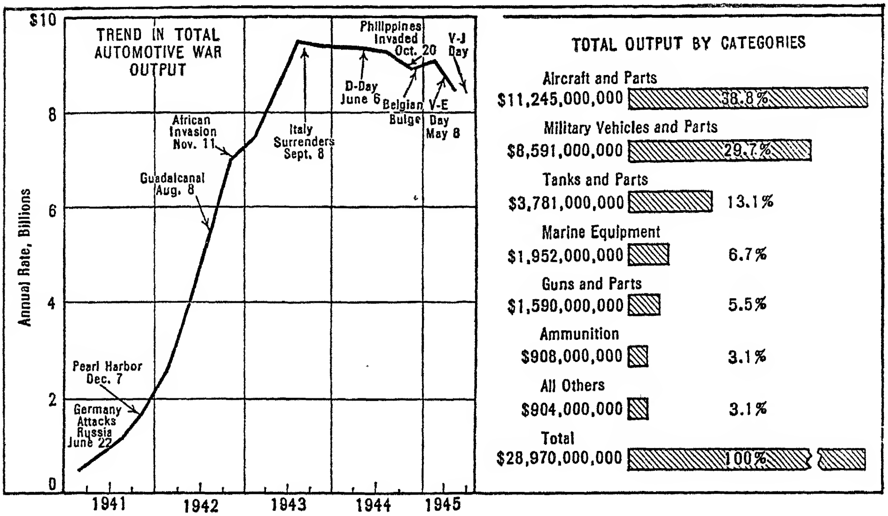
Production on the main assembly line gets under way when the frame is first placed on the conveyor, and, as it moves along, various parts are added: rear and front springs, rear axle, brake equipment, hydraulic brake tubing, propeller shaft, muffler, and gas tank. A complete engine, which has been built along a tributary assembly line in another part of the factory, swings out on a little crane, drops upon the moving frame, and is bolted on. The chassis is then painted with spray guns and moves through a drying oven, this being followed by the addition of wheels, steering gear, rear bumper, and rubber body mountings. A complete body, received from a subassembly line, is bolted in place, instruments are connected with the engine, and to the growing car are added running boards or side shields, front bumper, steering wheel, hood hinges, floor coverings, and the hood. Then the gas tank and radiator are filled, the engine is started, headlights are adjusted, the car gets its final inspection and moves off the line under its own power.

Task specialization has been developed to such a minute degree, plant layout has been so well organized, and the assembly process is so efficient that two or three cars, or more, may roll off the assembly line every minute of the day. On October 31, 1925, the main plant of the Ford Motor Co. established a record when it turned out 9,109 Model-T Fords in a single day, or more cars than it produced in the entire year of 1908. Henry Ford was the first to have faith in the mass production of a low-priced car made of standardized parts, in 1913 he was the first automobile manufacturer to introduce the use of the assembly line, and he has gone further than any of his competitors in obtaining control of the basic resources that enter into automobile production.[18] With increasing output, Ford was able

[16] While Detroit is the heart of the automobile industry, the leading companies maintain assembly plants in their chief markets in this country and abroad to which are shipped various parts and unit assemblies, such as frames, motors, and wheels, to be finally assembled into cars. This practice results in a great saving in freight for the manufacturer, since the parts needed to make 10 cars can be packed into the space occupied by 1 assembled car.

[17] See John G. Glover and William B. Cornell (ed.), *op. cit.*, pp. 686, 688-692.

[18] The Ford Motor Co. is a gigantic example of vertical integration of industry, since it controls so many of the steps in production from the production and assembly of raw materials to the manufacture and distribution of the finished product. The company makes or can make most of the things that it needs, even paint and glass. At River Rouge near Detroit are blast furnaces and two huge steel plants using iron ore dug from Ford mines near the head of Lake Superior and coal obtained from large landholdings in Kentucky. Scientific forestry is being practiced on the company's coal lands in Kentucky and on its timber lands in the Upper Lake Region. Ford vessels bring iron ore, limestone, and lumber down the Great Lakes and carry Kentucky coal from Toledo to Detroit. Ford barges carry finished products down the lakes and through the Erie Canal to New York. Ford ocean vessels take cars, trucks, and tractors to Argentina, returning with agricultural products. Huge Ford plantations along the Tapajoz River in Brazil are now ship-



American automobile plants were an important factor in winning World War II. The curve at the left shows the value of the war output in billions of dollars, year by year. The graph at the right shows the percentage of the different classes of war material to which these factories turned their equipment and staff during the war period. A somewhat similar graph might be made for dozens of smaller industries—typewriters for example—indeed a most amazing variety of plants changed over to war material.

to steadily reduce the price of his famous Model-T car from $950 in 1909 to $295 in 1922, and in the following year the Ford Motor Co. achieved its maximum production of over 2,000,000 cars.[19]

In 1927 the General Motors Corporation achieved leadership in the industry and since then has produced about 40% of the nation's automobiles, in recent years the Ford Motor Co. and the Chrysler Corporation each sharing about 25% of the total business.[20] To meet the individual needs of consumers, each of the "Big Three" produces a line of cars ranging from Chevrolet to Cadillac, Ford to Lincoln, and Plymouth to Chrysler, yet the great bulk of the revenue of the manufacturer comes from the production and sale of low-priced cars. While the low-priced car of today is more costly than that of the nineteen-twenties, it is a vastly superior car. In terms of quality it is still cheap, for in contrast with radios, washing machines, sewing machines, and mechanical refrigerators that cost between 40¢ and $1 a pound, the modern automobile can be made to sell for as little as 25¢ a pound.[21] In no other country have automobiles been made in such quantity, so well, and so cheaply.

ping crude rubber to the company's tire factory in Detroit. Throughout this country and in many foreign lands are Ford assembly plants that manufacture automobiles from parts shipped from Detroit. Thus, the Ford industrial empire, managed by a rugged individualist and without any domination by bankers, has become virtually independent of those who supply vital goods and services.

[19] Famed for their rugged construction and simplicity of operation as well as for their low price, Model-T Fords are still in operation in many parts of rural America today.

[20] The remaining 10% of the automobile market is shared by Crosley, Graham-Paige, Hudson, Hupp, Nash, Packard, Studebaker, and Willys-Whippet.—Evan B. Alderfer and Herman E. Michl, *op. cit.*, pp. 147-148.

[21] *Ibid.*, p. 149.

The total number of cars and trucks produced in the United States was:

1900	4,192	1929	5,621,715
1920	2,227,349	1940	4,469,354

Our Foreign Trade in Automobiles. While America has no monopoly on the mechanical or administrative skill requisite for the production of automobiles and motor trucks, our high domestic buying power has enabled us to lead the world in this branch of manufacture. France, England, and Germany still specialize largely in producing expensive custom-made cars, while most of the American manufacturers have adopted standard designs and quantity production. Europe makes fine cars but they are too costly for the average man. Europe is also an old continent, heavily populated, with many of its natural resources already on the decline, and a much lower per capita wealth. Hence it has not the consuming capacity for large numbers of automobiles.[22] Furthermore, just as millions of American office and factory workers find it cheaper and quicker to ride in busses, subways, and suburban trains to and from their daily work in congested metropolitan areas, so in crowded Europe, with its short distances, there is not the need for individual transportation.

American imports of motor cars have decreased until they consist of only a few high-priced and specially built cars. On the other hand, American Fords, Chevrolets, and Plymouths are shipped all over the world and driven in every land. The popularity of the standard makes of American low-priced and medium-priced cars has been due not only to cheapness and efficiency, but in no small measure to ease of repair. The car owner or local garage man in Argentina, Australia or South Africa is not dependent on a machine shop for his repairs, but can usually obtain from his dealer a duplicate part whenever needed and make the repairs himself. The average value of our annual exports of automobiles, parts, and accessories during 1935-39 was $268,000,000, ranking second only to raw cotton exports that were worth $319,000,000.[23]

The Motorcycle. The motorcycle, a development of the once-popular bicycle, provides one of our important minor industries. The motorcycle might have become still more popular in the world of transportation except for the fact that the cheap four-wheeled automobile approaches it so closely in price and far exceeds it in utility.

The lowly bicycle is not dead, despite the automobile's double attack. In 1939 we produced 1,253,000 bicycles and 3,525,000 motor vehicles of all types.

5. *The Manufacture of Railway Cars and Locomotives*

Size of Industry. In spite of growing competition from motor trucks, busses, and other carriers, the railroads remain the backbone of the American transpor-

[22] In Great Britain the Ford Motor Co. operates assembly plants at Manchester and Dagenham, the latter having an annual capacity of about 200,000 cars. Since the British rule-of-the-road is to drive on the left-hand side of the street and highway, the steering gear is placed on the right-hand side of each car.

[23] The importance of our automobile industry is further shown by the fact that in 1939 it used 80% of all rubber, 75% of the plate glass, 68% of the upholstery leather, 55% of the alloy steel, 51% of the malleable iron, 49% of the strip steel, 44% of the iron sheets, 40% of the mohair, 34% of the lead, 33% of the iron bars, 23% of the

tation system. In 1943 freight trains traveling more than 701,000,000 miles carried about 3,032,000,000 tons of freight, while passenger trains traveling 463,000,000 miles handled nearly 885,000,000 passengers.[24] To accomplish this, about 1,759,000 freight cars, 38,000 passenger cars, 43,000 locomotives, and 1,355,000 workers were needed. The manufacture and repair of railway cars and locomotives is a large industry in itself, for in 1942 the railroads spent more than $504,000,000 on the construction and repair of freight cars alone. Normally about 10% to 15% of the locomotives and 5% to 10% of the freight cars are in repair shops being overhauled, and more than 316,000 workers are needed just to keep railway cars and locomotives in repair, or about as many workers as are employed in the British cotton textile industry. Although every railroad has repair shops scattered along its lines at junction points and at ends of divisions, this work is, so far as possible, concentrated in the best locations.

Railway Cars. Illinois, with Chicago, the greatest railroad center in the world, leads all the states in the Union in the number of plants for the manufacture and repair of cars, and Pennsylvania leads in value of output. Since Chicago is the terminus of so many great railway lines serving the East, West, and South, many repair shops are needed within the Chicago area. At Pullman, a suburb of that city, is the largest passenger car factory in the world that makes coaches, baggage and express cars, and dining cars in addition to its nationally famous parlor and sleeping cars. At Michigan City, Ind., and in Chicago are huge factories that manufacture freight cars. From nearby Gary these factories and repair shops obtain their supply of steel, which years ago displaced wood in passenger cars and which is being rapidly adopted for making freight cars. Likewise, the freight-car factories of Butler, Berwick, and McKees Rocks, Pa., are well located in proximity to the great steel plants of the Pittsburgh area. St. Louis, a great railway center with easy access to the abundant wood supply of the South and with a rising steel industry of its own, has long been an important repair-shop center and manufacturer of railway and trolley cars.

In contrast with the standardized production of railway cars, repair work is an individual job. Because of the heavy wear and tear incurred in use, the repairing of cars involves twelve times as many men as car manufacture. The cost of new cars is two-thirds the average total cost of repairs. In the case of street cars, the ratio of repairs to cost is 3 to 1, repair work obviously being done in the localities where the cars are used. With the advent of the motor bus, thousands of miles of street-car tracks have been torn up, and the manufacture of street cars has declined.

Locomotives. For many decades Philadelphia has lead every city in the world in the making of locomotives. Some years ago the great Baldwin Locomotive Works moved their plant to Eddystone,

nickel, 14% of the copper, 12% of the zinc, 11½% of the tin, 10% of the cotton, and nearly 10% of the aluminum consumed in this country. Furthermore, 90% of all gasoline was consumed by automobiles.—John G. Glover and William B. Cornell (ed.), *op. cit.*, p. 680.

[24] In 1939 the railroads handled 62% of the total commercial inter-city passenger movement in the United States and 71% of the total in 1943. Of the total inter-city freight traffic, the railroads handled 64% in 1939 and 72% in 1943.—Letter of August 10, 1944, from Mr. Julius H. Parmelee, Director, Bureau of Railway Economics, Association of American Railroads, Washington.

a more roomy suburb on the banks of the Delaware, where about one-third of all locomotives in the country are now made. While the Philadelphia area has abundant skilled labor and easy access to a supply of good coal and steel, its leadership today is probably due to the impetus of an early start, for the manufacture of locomotives is an industry which, so far as the general situation is concerned, is almost equally at home anywhere between Chicago and New York.

Philadelphia's leading rival in locomotive manufacture is Schenectady, N. Y., home of the American Locomotive Company, a city which also produces so much electrical machinery. Other locomotive manufacturing centers include Lima, Ohio, and Pittsburgh and Scranton, Pa. Furthermore, both locomotives and cars are also made in some of the larger repair shops operated by the railroads. In 1939 the Pennsylvania Railroad exhibited at the New York World's Fair the largest passenger locomotive in the United States, weighing 525 tons and capable of developing 6,500 horsepower at a speed of 100 miles an hour, which had been built by the railroad in cooperation with three locomotive manufacturing companies.[25] It is obvious that the ease with which a locomotive can run to its place of final delivery on the American railroads makes this branch of machinery manufacture less dependent upon market and more dependent upon labor than are most kinds of machine manufacture. Few important industries approach locomotive manufacture in the extreme degree of fluctuation of prosperity. In periods of promising traffic and easy borrowing, the railroads order locomotives, and at other times they do not. Thus, in 1942, 1,255 locomotives were built as compared with only 12 in 1932. This is the perfect example of the sitdown strike of capital. If you want an eye-opener as to a potent cause of our industrial chills (depression) and fever (boom), hunt up the February, 1943, issue of *Harper's Magazine* and read four pages.

If you are interested in the future, that article is worth a journey of a hundred miles. The fact that it did not start a financial revolution is one of the many evidences of the remarkable capacity of the human mind to resist a new idea.

Looking to the future, three types of locomotives will undoubtedly be used—steam, Diesel, and electric.[26] Since Peter Cooper built the "Tom Thumb," America's first locomotive, at Baltimore in 1830,[27] steam locomotives have increased vastly in size, weight, power, and complexity, with the result that the most powerful locomotives can now haul a load of 13,000 tons exclusive of the weight of the engine and freight cars. Approximately 85% of all steam locomotives in this country burn coal, about a third of which are stoked mechanically, the remainder being oil burners that are used chiefly in our oil-rich

[25] Julius H. Parmelee, *The Modern Railway,* Longmans, Green & Co., New York, 1940, p. 90.

[26] See *ibid.,* pp. 91-92; Emory R. Johnson, Grover G. Huebner, and G. Lloyd Wilson, *Transportation: Economic Principles and Practices,* D. Appleton-Century Co., New York, 1940, pp. 52-58; and National Resources Committee, *Technological Trends and National Policy,* Washington, June, 1937, pp. 190-193.

[27] The first locomotive to be operated in this country was the "Stourbridge Lion," which was imported from England in 1829.

Southwest.[28] While the total number of steam locomotives in service decreased from 67,713 in 1925 to 41,755 in 1943, this decline has been largely offset by an increase in the average tractive effort of locomotives, enabling heavier loaded trains to run farther without changing engines.[29]

In recent years the electrification of railroads has made much progress, the number of electric locomotives in the United States increasing from 379 in 1925 to 892 in 1943.[30] Electrification makes flexible power available for use in the smallest of switch engines and the largest of passenger and freight locomotives, which have the advantage of cleanliness, rapid acceleration, regenerative braking, smooth operation at high speeds, and the ability to handle the heaviest of loads over steep mountain grades. The electrification of railroads has proved most profitable in areas where water power is cheap and coal is scarce, as in Switzerland, Norway, Italy, and our own Northwest, and also in areas of great traffic density, as between Washington and New York and between New Haven and New York, and in great terminal areas such as New York, Cleveland, and Chicago.

In contrast with the electric locomotive which derives its power from overhead wires or a third rail, the Diesel, or oil-electric, locomotive is a mobile power plant that converts the heat energy of fuel oil into mechanical energy and thence into electricity. Its power unit can be started and shut off almost as easily as that of an automobile. Prior to 1934 the Diesel had proved to be practical for switching and terminal work,[31] and since then it has been used increasingly for long-distance, high-speed passenger service to haul light-weight, streamlined trains, and, more recently, to haul heavy passenger trains consisting of cars of standard type. In 1943 there were 1,978 Diesel locomotives in service in this country, as compared with only 77 in 1930. Future competition between steam, Diesel, and electric locomotives should be interesting, and it should be emphasized that many possibilities remain for further improvement in the steam engine.

6. *The Aircraft Industry*

In contrast with the automobile industry, which achieved maturity in a remarkably short time, the production of aircraft is still in a stage of youthful and rapid development. Technology of manufacture is constantly changing, output fluctuates, and earnings are irregular. The location of production is

[28] Approximately three-fifths of all steam locomotives are used in freight service, nearly one-fifth are switch engines, the remainder being passenger locomotives or those that can be used for either passenger or freight service.

[29] Between 1925 and 1940 the average tractive effort of steam locomotives, or the force exerted at the rim of the driving wheel, increased from 40,666 to 50,905 pounds. In 1920 the route of the "Twentieth Century" of the New York Central between Harmon and Chicago was divided into 7 engine districts, requiring 7 engines for the trip, but now there are only 2 districts, and 3 engines are used to pull a heavier load. The Northern Pacific has one continuous run of 904 miles.

[30] The first small projects were completed in 1895, when the Baltimore & Ohio electrified 3.6 miles of tunnel under the city of Baltimore and the New York, New Haven, and Hartford electrified its Nantasket Beach line for about 5 miles. Between 1925 and 1940 the total electrified track in this country increased from 3,132 to 6,755 miles.

[31] The average switch engine spends most of its time doing nothing but burning coal. Many of our greatest railway gateways and terminals are afflicted with cold weather, which cuts about a third off the power of a steam locomotive but does not affect a Diesel.—National Resources Committee, *op. cit.*, p. 192.

frequently shifting. The use of aircraft, compared with the railroad and automobile, is small.[32] Future developments are highly uncertain. However, the fact that 234,000,000 miles were flown by airplanes on regular services throughout the world in 1938[33] shows that phenomenal progress has been made in the manufacture and operation of aircraft since that cold, historic morning of December 17, 1903, when Orville Wright flew the first successful power-driven airplane for 59 seconds over 40 yards of sandy seacoast about four miles south of Kitty Hawk, N. C.[34]

Lighter-than-air Craft. The production of aircraft involves the manufacture of two types of conveyances, those lighter than air and those heavier than air. Lighter-than-air craft include balloons, blimps, and huge rigid dirigibles. For buoyancy and lifting power, the gas bags of these craft are inflated with hydrogen or non-inflammable helium, virtually all of the world's helium supply being obtained from a gas field near Amarillo, Tex., that is a monopoly of the United States Government. While the balloon must wander aimlessly with the wind, blimps and dirigibles are propelled by the power of internal combustion engines.[35] The dirigible is built around a framework of structural steel and aluminum, with control rooms, living quarters, engines, and fuel tanks built into the lower part of the craft. Most dirigibles to date have been constructed at the Zeppelin works in Friedrichshafen, Germany, and at the Goodyear-Zeppelin plant in Akron, Ohio, and some have been made in England. Nearly all lighter-than-air craft are used for military and naval purposes, although a few dirigibles have been employed in passenger-and-mail services. Since all of the power of the motors is used for propulsion, proponents of the dirigible claim that it is more economical in fuel consumption than the cargo airplane for non-stop routes of 2,000 miles and that the saving in fuel would increase for longer distances.[36]

The Helicopter and Autogyro. Infant prodigy of aeronautical science is the helicopter, which was perfected just prior to World War II. This wingless

[32] In 1941 the airlines of the United States had operating revenues of 97 million dollars, as compared with 709 millions earned by highway carriers and 4,585 millions earned by railroads. About 3.8 million passengers were carried by airlines, 377 millions by inter-city busses and 251 millions by inter-city railroads. With fewer aircraft available for commercial transport in 1943, the airlines handled 3.4 million passengers, as compared with 963 millions carried by inter-city busses and 572 millions by inter-city railroads.—John H. Crane, "The Economics of Air Transportation," *Harvard Business Review*, vol. 22, no. 4, 1944, p. 496.

[33] Joseph B. Hubbard, "World Transport Aviation," *Harvard Business Review*, vol. 22, no. 4, 1944, p. 511.

[34] Later in the day Orville Wright's brother, Wilbur, flew the little biplane 284 yards. Both plane and engine had been built and designed by the Wright brothers, bicycle manufacturers of Dayton, Ohio, who had been experimenting with gliders. The tiny internal combustion engine of their craft had a maximum capacity of 16 horsepower and weighed only 107 pounds. For a discussion of the development of aviation, see Henry L. Smith, *Airways: The History of Commercial Aviation in the United States,* Alfred A. Knopf, New York, 1942; C. H. Biddlecombe, "Aviation: Historical Development," *Encyclopaedia of the Social Sciences,* vol. 2, The Macmillan Co., New York, 1930, pp. 339-347; and Emory R. Johnson, Grover G. Huebner, and C. Lloyd Wilson, *op. cit.,* pp. 259-278.

[35] The development of lighter-than-air craft began in France on June 5, 1783, when Stephen and Joseph Montgolfier placed a hot-air balloon in flight, and later that year a balloon carried passengers. In 1852 Henri Giffard equipped a balloon with a 3-horsepower steam engine that made a speed of 6 miles per hour. The first dirigible was completed on July 2, 1900, by Count Ferdinand von Zeppelin in Germany.

[36] Association of American Railroads, *Initial Study of Air Transportation,* Washington, January, 1944, pp. 17-18.

craft, often called the "flying windmill," depends upon a rotary vane above the fuselage for its lifting power and maneuverability. It is the only aircraft that can move up, down, forward, backward, and sideways under its own power and control. When equipped with pneumatic floats, it is the only aircraft that can light on or take off from water, ice, snow, mud, marsh, or dry land with no adjustment in landing gear. Because of its unusual maneuverability and because it requires only a few square feet of landing space, the helicopter may well be destined to play an important role as a vehicle of individual transport comparable to that of the motor car. The nearest approach to the helicopter in aircraft design is the autogyro, a small airplane equipped with a rotor that enables the craft to climb and descend at steep angles and to hover in a given spot.[37]

Airplane Manufacture in the United States. It is the airplane, however, that dominates the aviation industry of today and that has made possible the establishment of commercial airline routes across the continents and oceans of the world. So revolutionary has been this development that mankind's geographical thinking in terms of time and distance has been revised almost over night.[38] In the development of commercial aviation the United States, with its speed-minded people and long distances of travel, has led the world.[39] Under the stimulus of wartime demands, American airplane production reached a peak of 96,000 planes in 1944, as compared with a total output of 16,000 planes during World War I. While the wartime output consisted chiefly of military and naval craft, it included many cargo planes, and in 1944 the Army had on order 12,000 transport planes readily convertible to peacetime use. Many diverse types of airplanes are now produced to meet the varied demands of military, naval, commercial, recreational, and scientific services. Huge transport planes, carrying 40 or more passengers, are now commonly used in long-distance national and international services for the transportation of passengers, mail, and express. Smaller planes are employed on shorter routes and for taxi and charter services. Special types of craft are needed for photography, aerial surveying, forest patrol and fire fighting, crop dusting and spraying, and commercial advertising. The production and commercial use of airplanes and gliders for freight service is just getting under way.[40]

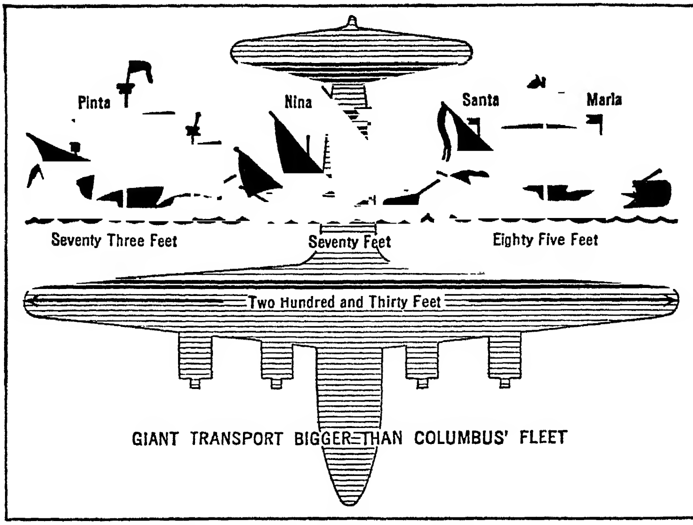
While the manufacture of airplanes in the United States at one time was concentrated in a few centers, such as Dayton, Ohio, and Hammondsport, N. Y., production is now widely scat-

[37] The first successful flight in an autogyro was made by Juan de la Cierva at Madrid, Spain, in 1923. Pioneers in the development of the helicopter were the Focke-Wulf Co. in Germany and Igor I. Sikorski in the United States. In 1942 a helicopter was flown for the Army from Stratford, Conn., to Dayton, Ohio, and in December of that year the Army placed the first quantity orders with manufacturers.

[38] See J. Parker Van Zandt, *The Geography of World Air Transport,* The Brookings Institution, Washington, 1944.

[39] With only 10% of the route mileage of the world in 1938, the domestic airlines of the United States accounted for 30% of the total miles flown. Between 1918 and 1943 the distance flown by airplanes carrying United States mail increased from about 16,000 to 98,000,000 miles.

[40] Cargo planes carrying 4½ tons of freight for 600 miles without refueling were used by the Armed Forces during the war. The heaviest load ever lifted by an airplane was that of the Navy's flying boat, "Mars," which carried 6½ tons of Christmas mail on a non-stop flight of 4,375 miles to Natal, Brazil, late in 1943, its total take-off weight amounting to 74½ tons.



Comparison of the fleet of Christopher Columbus with a modern airplane. Among many other things, it shows what metallic building materials will do, but copies of Columbus' ships would float longer than the modern giant of the air.

tered throughout the nation. Among the leading manufacturing centers at present (1945) are Baltimore, Md.; Philadelphia, Bristol, and Lock Haven, Pa.; East Hartford and Stratford, Conn.; Buffalo, N. Y.; Dayton and Alliance, Ohio; St. Louis and Kansas City, Mo.; Tulsa, Okla.; Fort Worth, Tex.; Seattle, Wash.; and Santa Monica, Burbank, and Inglewood, Calif. During the war many of our automobile manufacturers produced engines and other subassemblies for the airplane factories.

The mass production achievements of the automobile industry have not been duplicated in airplane manufacture, which as yet remains a job-lot type of production employing quasi-assembly-line methods.[41] Mass production of airplanes has been retarded by the limitation of the market, by the great variety of models, and by constantly changing design. After spending several hundred thousand dollars in designing an airplane, the manufacturer may be forced to adopt a newer and improved model when only a few planes have been made or even before production has started. While airplane factories are being equipped increasingly with automatic machine tools, as yet the bulk of the equipment consists of multi-purpose tools, such as the jig borer, that require highly skilled labor. The airplane is larger and more complex than the automobile and requires far greater precision of the individual worker. Thus, in the manufacture of an airplane motor some 5,000 parts are

[41] See Evan B. Alderfer and Herman E. Michl, *op. cit.*, pp. 166-173. As a result of wartime standardization of designs and improved production methods, the weight of planes produced monthly per worker increased from 23 pounds in 1940 to 73 pounds in 1944.—Aeronautical Chamber of Commerce, *Planes*, no. 1, September, 1944.

used, and approximately 25,000 inspections of workmanship are needed. Furthermore, the airplane assembly line is not moving continuously. For example, in the assembly of the fuselage, approximately 20 work stations are needed, and the main assembly line halts for several hours at a time while workers at each station install unit assemblies or subassemblies on each fuselage in various stages of completion. Hence, while 2 or 3 Fords, Plymouths, or Chevrolets may roll off an automobile assembly line every minute of the day, only 1 to 10 airplanes, depending upon the type of plane and the size of the order, come off an assembly line in one day. As the market for airplanes continues to grow and as greater standardization of the product is achieved, manufacturing technique will be improved, output will increase, costs will decline, and the rapid obsolescence in the use of airplanes will be reduced.[42]

Competitors of the United States. Outside of the United States the aviation industry has made greatest progress in Germany, Great Britain, Russia, France, Holland, Italy, and Japan. In Russia both the production and operation of aircraft are owned by the government, and in other foreign countries they have received generous governmental aid because of their strategic importance in time of war. It is from American and European manufacturers that other countries obtain most of their commercial and military aircraft.

The most important thing to say about the airplane industry is: Watch for a decade of swift change.

7. *Shipbuilding*

How Ships Are Built. The ship is the largest object that man can move, the most complex of all his devices, and the one with the most thoroughly correlated parts. The ship is too large an object to be made on a moving assembly line. The demand for ships in normal times is too small to permit the manufacture of parts by mass-production methods. The purchaser places an order with the shipbuilder and specifies in great detail the type of ship desired. These specifications depend upon the type and amount of cargo to be carried, the type of engines and speed desired, the length of voyages to be traveled, the port and climatic conditions to be encountered, and many other factors. Except in times of war, when ship types are standardized to permit speedy production, the ship is distinctly a custom-built or tailor-made job.

A model life-sized hull is first laid out on the floor of the mold loft with wooden or composition templates, or mock plates, that serve as patterns in the shipyard's plate and angle shop where steel plates are sheared, punched, countersunk, and bent to conform to the templates. Construction of the ship occurs on the "way," or foundation upon which scaffolding is erected to support the hull and from which the completed ship is allowed to slide into the water.[43] Construction begins with

[42] While a transport plane is serviceable for 8 to 10 years barring accidents, in this country it becomes obsolete in only 2 or 3 years. Many a second-hand plane from the United States completes its life span in Latin America and other parts of the world.

[43] In some places the method of building is varied by laying down the keel in a large drydock, from which the water is pumped but into which it is allowed to run to float the ship when it is finished. Sometimes for repair work, especially of war vessels, floating drydocks are con-

the laying of the keel plates, or steel plates laid in tiers. Then comes the vertical keel, or ship's backbone, a long girder that extends through the full length of the hull. Huge plates for the ship's bottom are attached to the keel. Longitudinal girders are bolted into position, followed by transverse frames, bulkheads, sides, and deck. In general, work begins amidships and proceeds in all directions, but the hull grows steadily upward like any building under construction. Before the hull is completed, the masts, engines, and heavy machinery are installed. When the ship is ready for launching, the keel blocks are removed, and the ship slides into the water with a mighty splash. Tugboats tow the vessel to the fitting basin, where interior painting, plumbing, small hardware, and electrical fixtures are added, but in Europe a vessel is seldom launched until absolutely complete. If the ship fulfills all requirements on its trial run, it is ready for delivery to the purchaser.

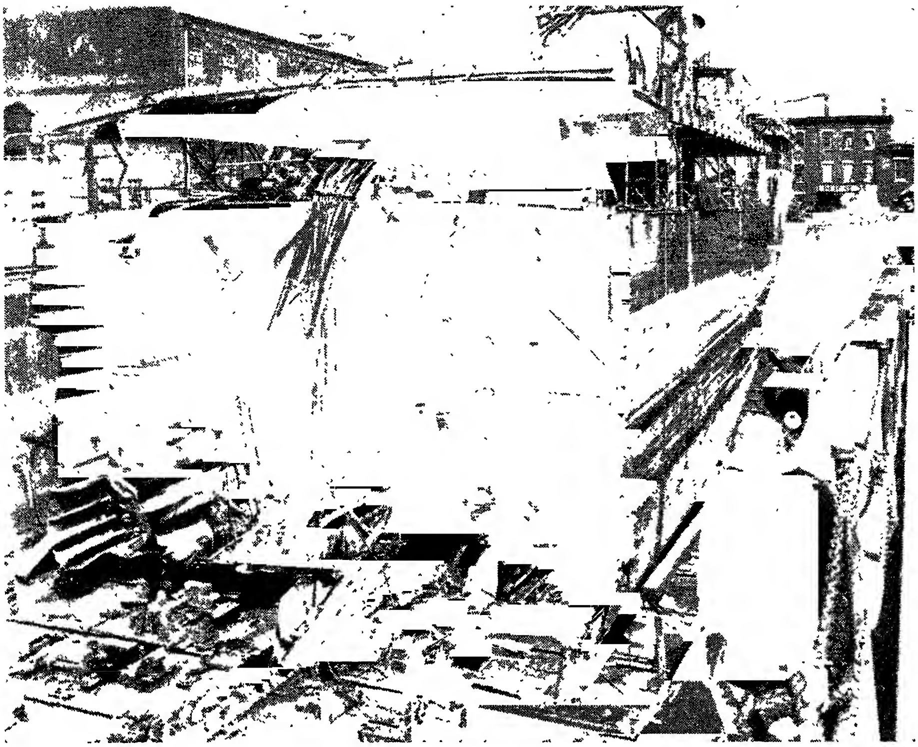
The method of ship construction shows the necessity of locating shipyards upon deep, quiet rivers with an abundance of available land along the shore. It is better that the shipbuilding river have fresh rather than salt water, because it is less injurious to the hull of the ship. All of the important shipbuilding localities are near steel and machine manufacturing districts.

Influence of Different Shipbuilding Materials. The American shipbuilding industry has had its ups and downs, due partly to the influence of the change in building materials. Prior to 1850 the world's ships were wooden sailing vessels, for which New England, with her pine forests, not far from the oak supplies of the Middle Atlantic States, had the best and cheapest material in the world.[44] All along her coast, especially in Maine, many shipyards were turning out vessels that were better and cheaper than those built in Europe. About the middle of the nineteenth century it was discovered that iron ships were better for most purposes than wooden ships, and their use rapidly increased. Iron was soon replaced by steel. In the supply of the raw material for this new type of ship, England, with her leadership in the iron and steel industry, was far ahead of the United States. Within the United States similar changes occurred, but this country was much slower to change from wood to iron and steel in hull construction and slower to shift from sails to steam. In the wooden ship era before the Civil War the output of the New England yards was nearly twice that of the Middle Atlantic and Gulf Coast, but the latter regions, adjacent to iron and steel supplies, now have many times the New England output.

British Leadership in Shipbuilding. Great Britain has long led the world in shipbuilding, and as late as 1893 her shipyards launched four-fifths of the world's merchant vessel tonnage. With the development of shipbuilding in other countries, the British share of the

structed which can be taken from place to place and do repair work where needed. A Brooklyn company has a floating drydock with the ability to lift clear of the water a ship 725 feet long and weighing 30,000 tons. The U. S. Navy has done wonders with the system.

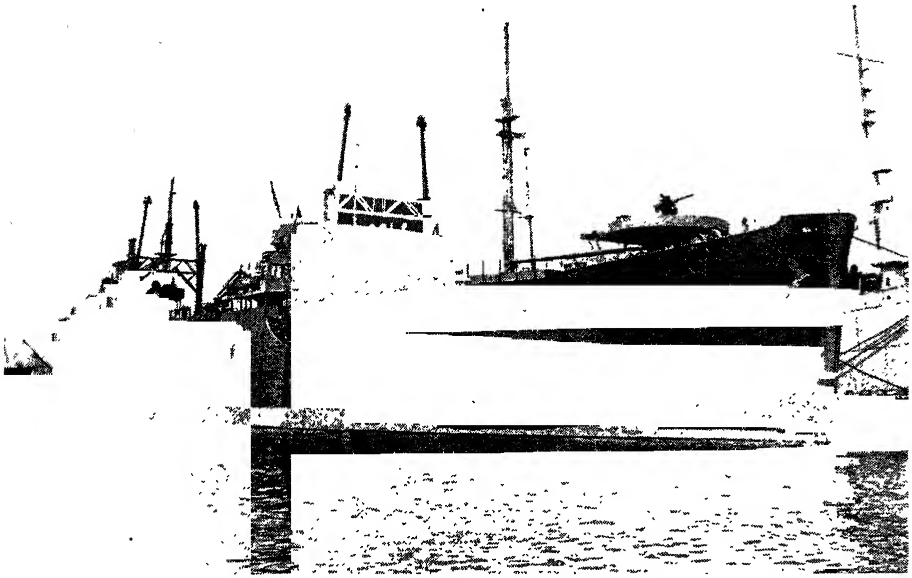
[44] In 1634 the first cargo of ship masts was exported to England, and for more than 200 years New England enjoyed a large and profitable trade in masts and ship timber. For an account of Great Britain's timber-supply problem, see Robert G. Albion, *Forests and Sea Power,* Harvard University Press, Cambridge, 1926.



One of the two halves of a tanker, ripped apart in mid-ocean by a torpedo. Because of her bulkheads, both parts could be towed to port.

While shipbuilding is carried on in many areas, the northeast coast of England, centering about Newcastle-on-Tyne and Sunderland, and the Clyde estuary below Glasgow, Scotland, generally produce about four-fifths of all British merchant tonnage. Along the northeast coast more than 40 companies build all kinds of ships but specialize in the construction of tramps, cargo liners, tankers, and war vessels. The Clyde region, with more than 30 shipbuilding firms, concentrates largely on passenger liner and naval construction, and here were built the great superliners, *Queen Mary* and *Queen Elizabeth*. Other important shipbuilding centers are to be found in northern Ireland at Belfast on the deep Lagan estuary and along the west coast of England at Birkenhead on the lower Mersey and at Barrow-in-Furness. Small craft are built along the shallow estuary of the Dee, and fishing boats are produced along the Humber. At Portsmouth, Devonport, and Chatham the Royal Navy operates yards for the construction and repair of war vessels. Many a British harbor, little more than a hole in the mud served by the dredged channel of

ping companies, but hundreds of war-built vessels merely rotted in our rivers and harbors. Total cost of Hog Island to the government was $235,000,000 for the ships and $65,000,000 for the yard, which was finally sold to the city of Philadelphia for $3,000,000 and converted into an airport.



Sixty-three days after the two halves of the torpedoed tanker reached New York harbor, she sailed out again, an achievement of which the shipbuilders were justly proud.

a small stream, is the site of a thriving shipbuilding industry.

For decades Great Britain has been the chief source of supply for the shipping countries carrying the world's ocean freight. Thus Norway, a land of sailors for fifteen centuries past, has had to turn to British yards for ships now that steel instead of Norwegian pine is the prevalent material. Not only do British shipyards build new ships for the merchant marines of many nations, but each year British shipowners sell old ships to shipowners in Japan, Italy, Greece, Spain, and other countries, some of these ships having a total life span of 25 to 40 years.[47] With the exception of a few Great Powers, the navies of many foreign countries depend upon British yards for their vessels. Hence, British-built ships fly almost every flag upon the sea. Of the 68,509,000 gross tons of merchant shipping in the world in 1939, the shipowners of Great Britain and its dominions possessed 21,002,000 tons (see Table 19).[48]

Development of Shipbuilding in Other Countries. The rise of the German iron and steel industry, the German merchant marine, and the German navy, caused the establishment of fine shipyards in the German ports of Stettin, Rostok, Lübeck, Kiel, and Hamburg which have turned out some of the fin-

[47] This policy of selling old vessels to the low-wage merchant marines of other countries was a major factor causing the decline of British tramp tonnage from 10,800,000 gross tons in 1914 to 5,500,000 gross tons in 1933.—See *Report of United States Maritime Commission on Tramp Shipping Service,* 75th Congress, 3d Session, House Doc. No. 520, Washington, 1938, pp. 12-18.

[48] Of the ocean-going steam and motor merchant vessels of 2,000 gross tons and over under construction on June 30, 1938, Great Britain was building 125 ships aggregating 1,023,000 gross tons; Germany, 92 ships, 710,000 gross tons; United States, 47 ships, 428,000 gross tons; Italy, 21 ships, 161,000 gross tons; France, 10 ships, 82,000 gross tons.

TABLE 19

GROSS TONNAGE OF WORLD'S MERCHANT MARINE

Nationality	*June 30, 1914*	*June 30, 1939*
British *	21,045,000	21,002,000
American †	5,368,000	11,470,000
Japanese ‡	1,708,000	5,630,000
Norwegian	2,505,000	4,834,000
German	5,459,000	4,483,000
Italian	1,668,000	3,425,000
Dutch	1,496,000	2,970,000
French	2,319,000	2,934,000
Greek	837,000	1,781,000
Swedish	1,118,000	1,577,000
Austro-Hungarian	1,056,000	....
Russian	1,054,000	1,316,000
Danish	820,000	1,176,000
Spanish	899,000	902,000
Panamanian	....	611,000
Finnish	....	580,000
Brazilian	324,000	488,000
Belgian	352,000	408,000
All other	1,062,000	2,922,000
World total	49,090,000	68,509,000

* British data include about 1.8 million gross tons under flags of British dominions in 1914 and 3.2 millions in 1939.

† American data include about 2.4 million gross tons on the Great Lakes in 1914 and 2.6 millions in 1939.

‡ Japanese data exclude sailing vessels.

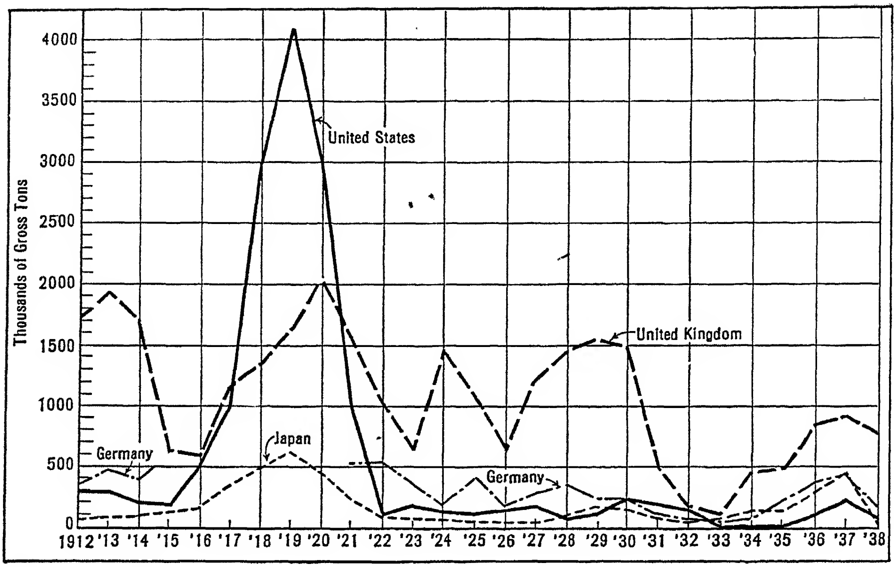
Source: Lloyd's Register of Shipping and *Foreign Commerce Yearbook.*

est ships afloat. At the conclusion of World War I, Germany was required to turn over her entire merchant marine, with the exception of about 500,000 tons of smaller vessels, to Allied nations in compensation for the wartime sinking of Allied ships by German submarines. However, by 1929 the German shipbuilding industry had restored the German merchant marine to nearly four-fifths of its prewar size, the newly built ships, chiefly oil-burners and Diesel motorships, proving very effective in world trade. From 1922 to 1938 the output of German shipyards usually ranked second only to the British.

The small but commercially important countries of Holland, Denmark, and Sweden have developed shipbuilding, using steel imported from Germany and Great Britain. The Dutch yards near Velsen on the North Sea Canal, the Danish yards at Copenhagen, and the Swedish yards at Goteborg and Malmo often turn out more merchant tonnage than is produced in France and Italy. In France there are shipyards in Marseilles, Havre, and Bordeaux; in Italy, at Genoa, Naples, and Venice, but the output of French and Italian yards seldom amounts to more than 5% of that of the British. In Soviet Russia ocean-going vessels are built at the Black Sea port of Nikolaevsk, the Baltic port of Leningrad, and the Amur River port of Komsomolsk which has a recently developed steel industry. In Japan, where both steel-making and shipbuilding are heavily subsidized, warships and high-grade merchant vessels are built at Kobe and Nagasaki.[49] In recent years, because of the wartime importance of a merchant marine, the shipbuilding industry of virtually every maritime nation has received some form of governmental aid.[50] As a result of shipbuilding developments abroad, the

[49] The importance of subsidization and cheap Japanese labor is shown by the fact that prior to World War II a cargo vessel that cost $1,000,000 to build in the United States, or $660,000 in Great Britain, could be sold by the Mitsubishi shipyards of Kobe for $550,000.—See Clayton D. Carus, *Japan: Its Resources and Industries,* Harper & Brothers, Publishers, New York, 1944, pp. 94-95.

[50] For an exhaustive analysis of subsidies, see Jesse E. Saugstad, *Shipping and Shipbuilding Sub-*



This graph of shipbuilding by the nations shows the first great American try at standardized shipbuilding during World War I; that the United Kingdom was the real peacetime shipbuilder, and the dreadful depression of the 1930's when the bulk of international trade shrank faster than the disappearance of ships, and left no demand for new tonnage.

sale of new British ships to foreign shipowners has declined.

Governmental Aid to American Shipbuilding. Virtually all maritime nations, with the notable exception of Great Britain, protect their shipping and shipbuilding industries by laws excluding foreign vessels from participation in the coastal trade. Since 1817 the American coastal and inland-water trade has been restricted to ships built and owned in the United States.[51] This is an interesting example of waste. A foreign ship, half empty, sails from New York to New Orleans or vice versa. Another ship sails alongside and carries cargo. Federal law also requires all vessels for our navy to be built in this country. For decades American shipyards have had to depend in normal times upon shipowners operating in the coastal trade and upon the United States Navy for the bulk of their orders. For decades American shipowners have found it very difficult to compete in international trade with the more cheaply built and more cheaply operated vessels of foreign nations, and at the outbreak of the war in Europe in 1939 only 23% of our total merchant tonnage was employed in foreign trade.[52]

In the United States modern ship-

sidies, Trade Promotion Series, No. 129, U. S. Dept. of Commerce, Washington, 1932, and supplemental reports.

[51] This reservation now applies not only to all water-borne traffic between ports within this country, including the large intercoastal trade between our Atlantic and Pacific seaboards, but also to trade between continental United States and Puerto Rico, Alaska, Hawaii, Guam, Tutuila, and American Samoa. Since 1912 foreign-built ships have been admitted to American registry, but as these ships are limited to foreign trade, American shipowners prefer American-built vessels that are permitted to engage in any trade.

[52] About 45% of American merchant tonnage was employed in foreign trade in 1830, 44% in 1860, 21% in 1890, and only 13% in 1914. The declining ability of our ships to compete for cargo

building is a high-cost industry flourishing under the abnormal demands of war and languishing during the long interims of peace. The inability of American shipowners to achieve the low costs prevailing in foreign shipyards is partly due to our methods, partly to the higher cost of materials, and especially to the higher cost of American labor. The normal practice of using special designs and equipment in the construction of American ships materially enhances their cost. While British shipyards are often able to reap some of the economies of large-scale production by laying down in adjacent ways the keels of six or more nearly identical vessels at one time, American shipyards seldom have on hand the orders to permit building more than one ship at a time. Although the f. o. b. mill price of steel plates and structural shapes is as low in this country as in Great Britain and Germany, our leading iron and steel centers are located much farther from tidewater, and these vital materials are burdened with higher transportation costs en route to the shipyard. Above all, shipbuilding is not adapted to assembly-line methods and requires a vast amount of skilled labor, and American wage rates are much higher than those abroad. Indeed, labor represents 32% to 40% of the total value of an American ship, as compared with only 16% of the value of an automobile.[53]

The handicap of high shipbuilding and ship-operating costs to the development of our merchant marine was recognized by Congress when it passed the Merchant Marine Act of 1936 authorizing the grant of construction and operation subsidies.[54] Under this act our shipowners are compensated for the difference between the cost of operating a vessel under the American flag [55] and what it costs competing companies to operate under foreign flags on those routes considered to be of importance to the foreign commerce of the United States. The government also pays the difference between the cost of building a ship in an American shipyard and the estimated cost of building a vessel of the same design abroad.[56] Furthermore, ships can be paid for under the install-

is shown by the fact that 90% of our total waterborne exports and imports was carried in American vessels in 1830, 67% in 1860, 13% in 1890, only 10% in 1914, and about 30% in 1939. These sad statistics show that with the coming of the railroad and the development of the continent, the American capitalist turned his eyes from the sea to the much greater chance for big and quick profits on land. In the footsteps of the pioneer, the American dollar went west!

[53] Evan B. Alderfer and Herman E. Michl, *op. cit.*, pp. 130, 167, and John G. Glover and William B. Cornell (ed.), *op. cit.*, p. 648.

[54] At this time the government abolished the old subterfuge of paying American lines huge sums for the carriage of mail that were greatly in excess of actual cost. For detailed accounts of American shipping and shipbuilding policy, see U. S. Maritime Commission, *Economic Survey of the American Merchant Marine*, Washington, 1937, and Paul M. Zeis, *American Shipping Policy*, Princeton University Press, Princeton, 1938.

[55] Owners of ships flying the American flag are prevented from hiring cheap foreign labor by federal laws requiring all officers who take charge of a watch to be American citizens and requiring three-fourths of the crew of each department of a ship to be able to understand all orders given by the officers. American shipowners must provide better food, quarters, and life-saving equipment and must meet labor-union standards as to wage rates and hours of labor. These requirements make American ship-operating costs higher than those of other nations.

[56] Thus, the *America*, our largest passenger liner measuring 26,482 gross tons, was built by the Newport News Shipbuilding & Dry Dock Co. for the United States Lines at a cost of $15,750,-000, which was paid by the government. The shipping company paid the government $10,500,-000, or the amount that the vessel would have cost if it had been built abroad. In this instance shipbuilding costs in Holland were used as a basis for comparison. Under the law the government will bear up to 33⅓% of the actual American cost, and in some cases, up to 50%, but if the

ment plan. The purchaser must make a down payment of not less than 25% of the estimated foreign cost of the vessel at the time of construction and is permitted to pay the balance with interest at 3½% in 20 annual installments, the government holding a first mortgage until all payments are made. All ships built with governmental aid must be approved by the Maritime Commission, which thus far has wisely limited aid to the construction of cargo, tanker, passenger, and combination cargo and passenger vessels. With the exception of passenger liners, which are individualistic, the required use of standard designs and identical templates, ship plates, engines, and equipment in building ships of each class has helped to reduce construction costs. In order to speed up the replacement of obsolete ships in our rapidly aging merchant marine, the Maritime Commission in 1938 began a shipbuilding program calling for the construction of 50 merchant vessels annually over a period of 10 years.[57] The program had scarcely begun when the outbreak of war in Europe caused our shipyards to be swamped with foreign and domestic orders for an unprecedented volume of merchant and naval tonnage. Under the pressure of wartime demands, the output of American shipyards increased from 0.4 million gross tons in 1940 to 0.7 millions in 1941, 5.4 millions in 1942, 12.5 millions in 1943, and 11.4 millions in 1944. No nation, past or present, ever achieved such a shipbuilding record.

The American Shipbuilding Industry. About three-fifths of our total merchant vessel tonnage is normally built in shipyards that cluster about the spacious waters of New York harbor, the Delaware River and Bay, and Chesapeake Bay. Among the leading yards in the New York area are those of Staten Island, Brooklyn, and Kearny, N. J.

The Delaware, sometimes called the American Clyde, with yards at Philadelphia, Camden, Chester, and Wilmington, is the most important shipbuilding river in America. The Clyde is but a creek dug out at great cost, while the Delaware is a wide, open estuary with room enough to build the shipping for all the world.

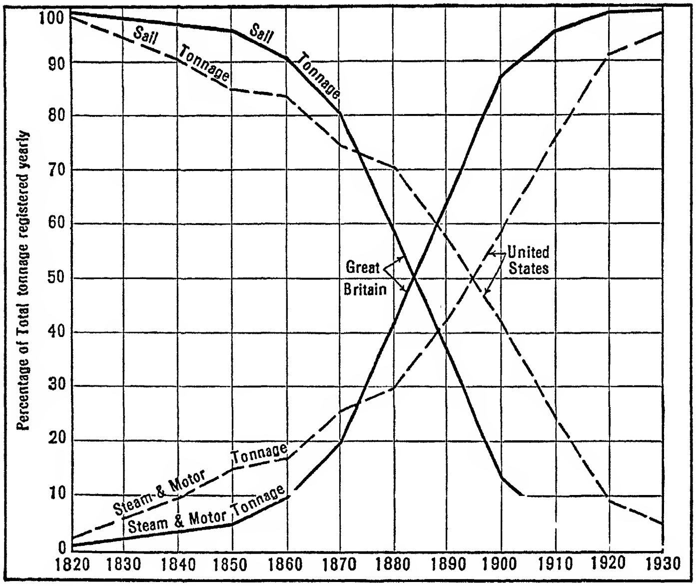
Along Chesapeake Bay are great shipyards at Sparrows Point near Baltimore and at Newport News at the mouth of the James River. All types of merchant vessels and some of the world's largest battleships are built in this Middle Atlantic shipbuilding region, which has a large supply of skilled labor and which obtains its steel from Sparrows Point[58] and from the Pittsburgh area, its machinery and engines from the factories and shops of the East, and its coal from Appalachia.

New England lost her shipbuilding supremacy when wood gave way to steel in hull construction, and now this region normally produces little more

shipbuilder's profit exceeds 10%, the surplus is recaptured by the government.

[57] The commission planned to sell or lease the ships to American shipowners, and, if it failed to do this, it was prepared to operate the ships itself. With the development of wartime demands, it had no difficulty in selling the ships.

[58] The largest shipbuilding company in the United States is the Bethlehem Shipbuilding Corp., a subsidiary of the Bethlehem Steel Corp., the nation's second largest producer of steel. This company owns shipyards at Sparrow's Point, Quincy, Staten Island, and on San Francisco Bay. Next in size are the Newport News Shipbuilding & Dry Dock Co. (Newport News, Va.) and the New York Shipbuilding Corp. (Camden, N. J.). The Federal Shipbuilding & Dry Dock Co. (Kearny, N. J.) is a subsidiary of the United States Steel Corp.



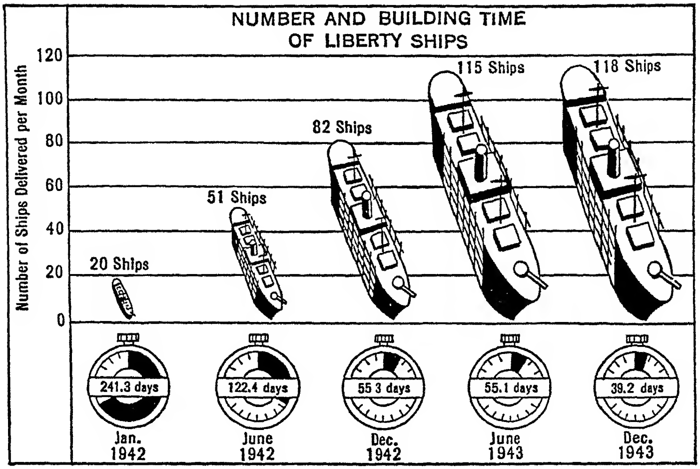
Swift was the descent of sail, although it lingered a little longer in the land of schooners than in the land of square riggers. Note that this is building and registering—not use. The registrations of any year expect to sail for decades.

than one-tenth of the nation's tonnage. Many types of large vessels are constructed in the modern shipyard at Quincy, Mass., smaller craft being built at Groton, Conn., famous for its submarines, and at Bath and South Portland, Me. Since much of the work of shipbuilding occurs out of doors, New England yards are handicapped by interruptions caused by heavy snow, ice, and bitter cold in winter.

Although the Gulf and Pacific Coasts have climates conducive to year-round shipbuilding activity, neither region has developed an important shipbuilding industry in times of peace. Both regions are handicapped by limited steel-making facilities and by distance from the nation's major steel centers. Along the Pacific Coast labor costs are comparatively high, but the climate is certainly the best in the United States for out-of-doors shipyard work—cool in summer, mild in winter. Among the older shipyards of the South are those of Tampa, Fla., Beaumont, Tex., and Mobile, Ala., and almost over night new yards were created to meet wartime demands at Wilmington, N. C., Pascagoula, Miss., New Orleans, La., and Houston, Tex.

Following the liquidation of the World War I shipbuilding program, no ocean-going merchant vessels were launched along the Pacific Coast until 1939, peacetime activity consisting of naval construction and repair work. In common with shipyards throughout the country, the yards of Seattle, Portland, and the San Francisco and Los Angeles areas boomed during World War II, when speed rather than economy was vital in the mad race to produce tonnage.

Shipping upon the American Great



Here's the record of the greatest shipbuilding achievement that ever happened or will ever happen again, for only a war, a long war, could make another and there are small prospects of any more long wars.

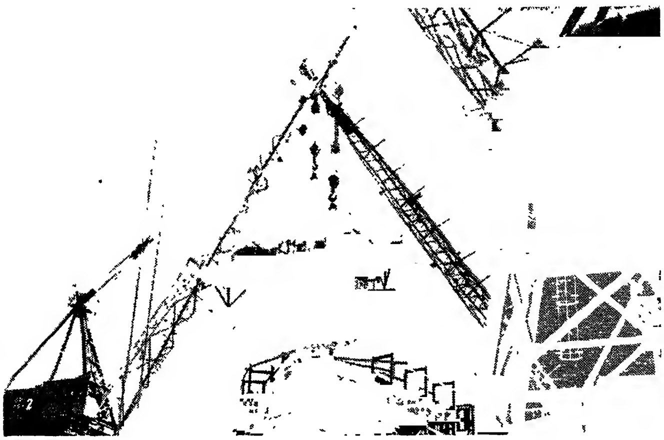
Note the output per month and the circular graphs at the bottom, showing the remarkable reduction in the length of time required to build a ship.

Lakes renders great commercial service and the vessels, being so large that they cannot leave lake waters, are built upon the lake shores. The most important centers are at Cleveland, Chicago, Detroit, and Buffalo, although there is some shipbuilding at the Lake Erie ports of Lorain and Toledo.

American Navy Yards. The enlarged Navy of the United States requires government Navy Yards equipped for the repair of war vessels. As these repairs are often extensive, some yards are now able to build, and have built, battleships and should therefore be ranked among the important shipbuilding enterprises of the United States. They are located at Portsmouth, N. H.; Boston, Mass.; Brooklyn, N. Y.; Philadelphia, Pa.; Norfolk, Va.; Charleston, S. C.; Bremerton, Wash.; and Mare Island, Calif.

Shipbuilding During World War II. The need of building ships fast enough to beat the submarine made standardization of shipbuilding in the United States an absolute necessity throughout World War II. By minutely standardizing the vessels and limiting them to a few types, the builders were able to use the machine shops of the whole nation, rather than remaining dependent upon works immediately beside the river bank. Thousands of duplicate parts were manufactured for hundreds of duplicate ships. Like knockdown houses, parts of vessels were made all over inland America, partially assembled, delivered at the shipyards, and put together with all possible speed. To assure the delivery of parts and equipment when needed and to prevent traffic congestion at seaboard, a central buying and traffic office was set up by the Maritime Commission to control the vast flow of supplies constantly moving to shipyards.[59] Many ingenious methods

[59] For excellent accounts of our prewar and wartime shipping and shipbuilding programs, see *Fortune*, vol. 16, September, 1937; vol. 24, July, 1941; and vol. 25, May and June, 1942.



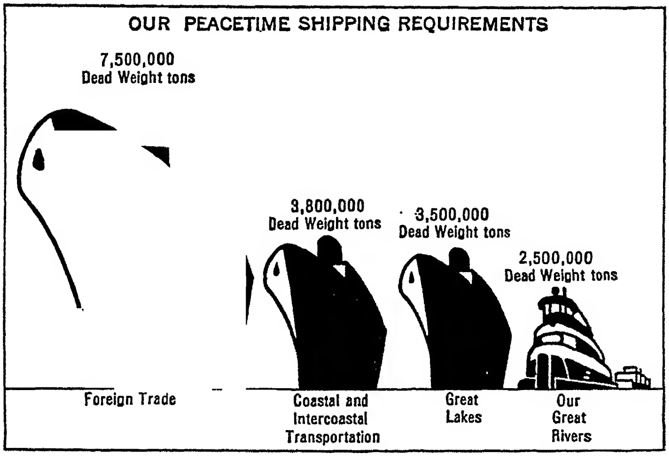
How did they manage to build the ships so fast? Here's one of the answers. In addition to being completely standardized, the concept of the assembly line was applied. Here four booms are swinging a prefabricated 90-ton deck house into place. This system permits machine shops on land to do much of the ship work, and it can be done to better advantage on land than in the awkward positions and restricted locations required by work on the ways in a standard old-fashioned shipyard.

were devised by the shipbuilders for subassembling various sections of a vessel on the ground prior to final assembly on the ways. Giant cranes were employed to lift prefabricated deckhouses, inner bottom and side shell sections, frame castings, massive bulkheads, and other units into place, some units weighing as much as 260 tons. Indeed, certain firms were able to construct as much as 50% of a Liberty cargo ship off the ways. Never before was labor-saving machinery used on such an extensive scale. The result of carefully planned multiple production of ships of identical patterns is shown by the fact that the number of Liberty ships completed by our shipyards increased from 20 in the month of January, 1942, to 118 in December, 1943, while the average time required to build a ship was reduced from 241.3 to 39.2 days (see Fig. 293). Some of these ships were completely built in less than 7 days.

Outstanding product of standardization during World War II was the Liberty ship, or "ugly duckling," that was modeled after a modern British tramp, being designed for capacity rather than speed.[60] This practical seagoing "truck," capable of carrying 10,500 tons of cargo at a speed of 11 knots, was easy to build, operate, and repair. In addition to the construction of about 2,000 Liberty ships, many high-speed cargo ships and combination passenger and cargo vessels, tankers, ore carriers, coastwise ships, and other craft were turned out by American shipyards and should prove useful in the postwar era.[61]

[60] The Liberty ship is about 441 feet long and 57 feet wide and is equipped with 5 large cargo holds divided by 7 watertight bulkheads. Because of the bottleneck in the production of turbines, gears, and electrical equipment during the early years of the war, the Liberty was equipped with old-fashioned, 2,500 horsepower, steam reciprocating engines. The Liberty proved to be a much better ship than the Hog Islander of the previous war.

[61] Construction of the Maritime Commission's streamlined C-type vessels of prewar design con-



The better utilization of our resources will probably cause relatively increased need for coastal tonnage and river tonnage.

While standardization was the keystone of our wartime shipbuilding program, it is not suited to the shipbuilding industry as a whole in times of peace. However, many of the economies learned during the war can and will be used in the future, particularly in the construction of cargo ships and oil tankers. From World War II the United States emerged with the world's greatest shipbuilding industry, the world's largest navy, and a huge merchant marine.[62] Many of the less effective ships and shipyards undoubtedly will be scrapped in postwar years just as happened after World War I. Nevertheless, the United States, with its two-ocean coastline, two-ocean navy, world's largest export trade, and an import trade second only to that of Great Britain, has definite need for an efficient merchant marine backed by a strong shipbuilding industry (see Fig. 295).

8. *Small Metal Manufactures*

Relation to Good Labor Supply. An inspection of a hardware store reveals a collection of hundreds and even thousands of articles, such as saws, axes, cutlery, firearms and ammunition, radio sets, plumber's, tinner's and carpenter's tools, and that very long list of articles known as builders' hardware, nearly all of which are made of metal. A jewelry store reveals a collection of still more valuable metal products in which, as in the hardware, the metal plays a relatively small part, and the labor a large part in the cost of production. This high

tinued throughout the war. Production of Victory ships began in 1944, this ship being of about the same size as the Liberty but having 6,000 horsepower geared turbine engines capable of making a speed of 15 to 16 knots. A Victory ship could make the voyage of 6,590 miles from San Francisco to Sydney, Australia, in 16 days, as compared with 21½ days required by a Liberty ship.

[62] According to estimates by the Chamber of Commerce of the United States, our merchant fleet in January, 1941, consisted of 1,150 ocean-going ships of about 7,000,000 gross tons, compared with a world total of 50,000,000 tons. At the end of the war, this country will have 3,500 ships of well over 20,000,000 gross tons, including about 2,000 Liberty ships.—Shipbuilders Council of America, *Ships*, no. 8, May, 1944, p. 14.

labor and small material value means that these articles are likely to be produced where population is abundant, labor is skilled, and manufactures well established, as in New England, not where they are scarce, as in Arkansas, Dakota or Oregon.

The Distribution of the Industry. The manufacture of most of these small articles in the making of which machine tools and automatic machinery are very important, particularly in America, orignated in England and in Germany. It soon started up in this country, in southern New England, the home of the so-called "Yankee notions," and has gradually moved westward through New York and Pennsylvania into the North Central States. Thus, the town of New Britain, Conn., with its skilled labor supply, manufactures about one-tenth of the hardware of the country, but at the monster steel plant at Gary, Ind., iron ore is unloaded from the lake steamer at one end of the plant, while from the other end are shipped many small articles that may be bought in a hardware store. The Vermont towns of St. Johnsbury and Rutland make a large part of the fine scales that weigh goods all over the United States and in many foreign countries, but the manufacture of scales is also well developed at Toledo, Ohio. Connecticut has long led the nation in the manufacture of clocks, watches, and parts thereof, especially the cheaper variety, but Elgin, Ill., is an important competitor.[63] Springfield, Mass., and the Connecticut cities of Bridgeport, New Haven, and Hartford normally make about two-thirds of the firearms in the United States, but during the war this industry was developed on a large scale at scattered points throughout the country. About one-third of all jewelry, ranging from ten-cent store brilliants to the best plate and solid metal, is produced within 30 miles of Providence, Rhode Island, our most densely populated state, but the remaining two-thirds is now made largely outside of New England. Connecticut manufacturers of silverware face competition from Buffalo, N. Y., and other centers. That New England is able to retain her leadership in small metal manufactures is due partly to Yankee skill and ingenuity, partly to the impetus of an early start, and very largely to the fact that the varied products of this industry require much skilled labor and little raw material and that the small, high-valued finished products are easily able to stand high transportation charges to many markets.

In this class of industries it is plain that America is at a disadvantage with Europe in the combined factors of labor and raw materials. We have made advantages by inventions, in which we have thus far led the world. Most of the articles of this type are patented, such as firearms, and typewriters, of which one factory in central New York exports several million dollars' worth per year to many foreign lands. Sometimes the patent control lies not in the design of the article but in the method of making. Skill and fine workmanship make the cutlery and silver plate of Sheffield, England, known all over the world. When it comes to plain unpatented, simple things, labor decides it, as in the case of toys, of which the world's sup-

[63] Among the high-grade watches, the Waltham is made at Waltham, Mass.; the Hamilton, at Lancaster, Pa.; and the Gruen, at Cincinnati, Ohio.

ply comes so largely from south Germany and from Japan.

Standardization and Interchangeable Parts. The New England clock business has been made possible by the American system of manufacture, in which standardization and interchangeable parts have replaced the old hand methods by which every clock was different. Switzerland has long been famed as the best watch-making country in the world, Geneva and vicinity being the center. These watches are made by hand, each wheel carefully fitted to the next wheel, so that if one breaks the new one has to be shaped by hand to fit its mates. By the American method of interchangeable parts, fifty watches can be taken to pieces, each piece put into its own bin, and the watches may then be satisfactorily reconstructed by chance selection of the necessary parts. Thus, Connecticut can make alarm clocks and cheap watches at extremely low prices, because of new methods of manufacture, perfected largely through American inventions. The house furnishing store has now entered the class of machine dealers, witness 16,799,000 vacuum cleaners in use in the United States in 1944. The number of kinds of useful machines is rapidly increasing—adding machines, writing machines, printing machines, talking machines, picture machines—of the making of machines there is no end.

The mechanical methods of manufacture, in combination with the patented devices owned by American firms, have enabled the manufacturers of New England, New York, Pennsylvania, and Ohio, to sell builders' hardware, rifles, bicycles, clocks, typewriters, and many other patented articles in many foreign countries, despite the fact that England and Germany have cheaper material and cheaper labor. Apparently this trade can only be kept up by the continued improvement of the patterns and methods, for if an article, like a microscope for instance, falls into the class where it is a plain matter of labor and skill, it is made where skilled labor is cheapest. Thus America has never thought of establishing a wood-carving business. It belongs in Europe as the yet more difficult ivory carving and lacquer-work belongs in the Far East with its cheapest and most skillful of all labor. Indication of this adjustment of industry to population is shown by the complaints of German makers of cheap clocks that Japan was selling them in China at prices no European manufacturer could meet.

European Jewelry Centers. The centralization of jewelry-making in the United States around Providence is matched in England by the leadership of Birmingham, and in Germany by the towns of Pforzheim and Hanau. Pforzheim became the residence of fleeing French Huguenot jewelers, and the industry was well established 150 years ago. By 1907 there were 1,078 factories, and 24,000 workers, a number nearly equal to all those of the United States; and in 1935 there were 1,200 firms and about 20,000 workers engaged in the industry. The town has special schools to train jewelry workers, many of whom work in their own homes. Hanau has worldwide fame for its manufactures of jewelry and jeweler's novelties. The fact that highly skilled workmen can be secured in Hanau for a very cheap wage is its only advantage, as all the raw materials must be imported.

Before World War II the town of Gablonz, in Czechoslovakia, was a great center for costume jewelry. It was also made in Saxony and Japan.

It is apparent from the nature of small metal manufacture that those industries that are dependent upon skilled labor and the reputation of their products for success sooner or later will encounter competition. Labor today is more mobile than ever before, it can be more easily trained to acquire new and amazing skills, and the skill of the human being continues to give way to the greater precision of the machine.

9. *European Machine Manufacture*

The European manufacturing districts have in their midst a machinery manufacture similar to that of the United States. The most important manufacturing region in this country, a quadrangle bounded by a line connecting Boston, Baltimore, St. Louis, Milwaukee, thence back to Boston has its counterpart in Europe, within a rough circle connecting Glasgow, Bergen, Stockholm, Danzig, Cracow, Budapest, Florence, Barcelona, Bilbao, Belfast, and thence back to Glasgow. This European manufacturing district is older, its industries are in some respects more advanced, more mature, and more refined than those of America.

Importance of Cheap Labor. One of the most conspicuous differences between American and European machine manufacture is the greater element of labor value in much of the European output. This arises naturally from the cheaper labor of Europe. The high cost of labor in America has driven us to the second difference, the greater degree of inventiveness which shows itself in the excellence of our automatic, power-driven machines and the superior design of many of our machine tools. It is manifestly design, rather than cheapness of material or skill of workers, that causes the great Swiss firm of Sulzer, manufacturer of engines, pumps, and refrigerating machinery, to secure about half of its machine tools in the United States.

Establishment of American Branch Factories Abroad. Since World War I. many branch factories have been established by large American corporations in Europe for the manufacture of agricultural implements, automobiles, tires, telephones, sewing machines, cash registers, business machines, shoe machinery, electric refrigerators, excavating machinery, and other products. In some cases these factories are merely assembly plants that assemble parts manufactured in the United States. In other instances these establishments manufacture products from European or imported raw materials. In every case these branch factories represent an export of American capital and technical knowledge. Among the causes underlying this movement to establish American factories abroad are the desire to escape paying high foreign tariffs, to save transportation charges by locating a factory in the midst of an important foreign market, to be able to provide better service and repair facilities, to overcome local prejudice against imported goods, and to meet the requirement of some foreign patent laws that all patents registered in the country must be worked through local manufacture if the patent is to be maintained.

In modern times many important inventions originate in the laboratories of the great corporations, and it is natural that such corporations should provide the capital and industrial experience for the development of these inventions abroad. It is also natural that an American corporation should prefer to invest its surplus funds in manufacturing its own products abroad rather than to develop a new line of products unrelated to its business at home. When American branch factories are established abroad, the introduction of our production methods abroad does not always result in such low costs as are attained in this country, for the achievement of low costs in manufacturing depends not only upon methods but upon quantity production and upon cheap and abundant natural resources, with which America is singularly blessed.

The European machine manufacturing plants are usually smaller than those of the United States. As the home market is usually the main dependence there as elsewhere, the possibilities of market have been much smaller than in America, and the rapid expansions so common in America are not common in Europe. Our huge automobile and locomotive plants, which sometimes increase their output several hundred per cent in a year's time, are a source of wonder to most Europeans, but one significant fact should not be overlooked. World War I forced European munition makers to standardize and specialize. They achieved an excellence in munitions that we did not attain until World War II. The future—?

. . . 11

Chemical Raw Materials and Manufactures

1. Chemistry in the Laboratory and Factory

Chemistry, the science, and the chemical industries are of universal importance in manufacturing. The printer depends upon them for his ink, the railroad builder for his dynamite, the blacksmith and the tinner for materials to make their metals weld, the glassmaker and iron manufacturer for chemicals for fluxing and reducing ores. The chemist produces the painter's colors, the dyes of the weaver, the tans of the tanner, the fertilizer for the tiller of the soil, the drugs and medicines for the apothecary and the physician, and raw materials and commodities without number. The processes of the chemical laboratory which supply these necessities are coming more and more to be performed in factories on a large scale (the work of the chemical engineer), as the basis of a rapidly growing industry of an importance in manufacturing that is to be likened only to the use of power.

We are living in an era of chemical discovery that ultimately may be as revolutionary, perhaps even more revolutionary in its industrial consequences than the Mechanical Revolution which resulted from a new, larger, and better use of energy. The Chemical Revolution now under way arises from a deeper understanding and a more effective use of matter.[1] Key man in this new revolution is the research chemist who by the use of such forces as heat, light, pressure, and electricity is able to break down existing combinations of molecules and atoms and rearrange them in new combinations. As a result of research costing many millions of dollars a year,[2] there emerges from the great chemical laboratories of today an endless and increasing stream of new products, new uses for old products, and new processes of manufacture. Chemical research is constantly bringing about the creation of entire new industries and vital changes in others, while for some industries it means competition and utter ruination.[3]

[1] See Edwin E. Slosson, *Creative Chemistry*, The Century Co., New York, 1930, and Williams Haynes, *Men, Money and Molecules*, Doubleday, Doran & Co., Inc., Garden City, N. Y., 1936.

[2] The great American public now spends but little more for fundamental research in all the sciences than it does for chewing gum.—National Resources Committee, *Technological Trends and National Policy*, Washington, June, 1937, p. 366.

[3] Manufacturers go to bed satisfied that all is well with the world only to wake up the next morning to find that their businesses have been swept away while they slept. Hence, some bankers feel that research is an activity that serves only to make banking hazardous, for the recipient of a bank loan may be prosperous today and bankrupt when the loan comes due.—See *ibid.*, pp. 290-291. It has often been noted that when a banker becomes a member of the board of directors of a manufacturing enterprise he opposes research. Perhaps bankers must be conservative by nature, otherwise they would not be bankers.

The factory by the sea. Sixteen million dollars' worth of plant at Freeport, Texas, for winning magnesium and bromine from sea water. The big tanks at the left are each 200 feet in diameter. The black "forest" at the right is the black metal of a chemical plant—capacity 36 million pounds of magnesium per year. At last we have found an inexhaustible mine, but the plant uses lime and it takes fuel to make that.

The chemical engineer in the factory knows from experience that many a promising discovery in the laboratory is not always practical under conditions of large-scale production, for when the apparatus is enlarged to factory size to handle large masses of raw materials the results may be quite different. After a new product or process has passed its laboratory tests, the chemical manufacturer may build a small factory, or pilot-plant, in order to ascertain the effects of production on a semi-commercial scale and to make whatever readjustments are necessary. Thus, without tying up too large an investment, much of the vital "know-how" of production is learned. Finally, the new product or process is ready for large-scale production, which is conducted by less skilled workers who merely follow standard instructions which have been carefully prepared by the chemical engineers and laboratory technicians.[4] Indeed, one of the greatest achievements of the American chemical industry has been the development of the continuous process permitting large-scale operations and resulting in a saving in time, a more uniform product, and smaller losses in production. Almost every day some new molecular combination is discovered or some new set of chemical reactions is so perfected that another laboratory process may become an industrial process, with the result that the prices of many chemical products are rapidly declining and the output rapidly increasing.

2. *The Rise of the Chemical Industry*

Early British and German Leadership. Of all the tools or agents used by the chemical industry, the most essential are acids and alkalies, and of these

[4] So important is research that the chemical industries of this country in 1937 employed 300 research workers for every 10,000 wage earners hired, as compared with 20 in the iron and steel industry and 3 in textile manufacturing.—Evan B. Alderfer and Herman E. Michl, *Economics of American Industry,* McGraw-Hill Book Co., Inc., New York, 1942, p. 224.

none are of greater importance than sulfuric acid and soda ash. The first great stimulus to chemical manufacture occurred when the textile industry moved out of the home into the factory, for the large-scale production of textiles by power-driven machinery greatly increased the demand for sulfuric acid and soda ash needed in the manufacture of soap, bleaching powder, detergents, and dyes. Fortunately, two outstanding developments enabled chemical manufacturers to meet the growing demand. One was the beginning of sulfuric acid production on a commercial scale in a lead-chamber process plant established by John Roebuck at Prestonpans, Scotland, in 1749.[5] The other was Nicolas Le Blanc's discovery in 1791 of a method for making soda ash from salt, sulfuric acid, and limestone, followed by the erection of small soda works at St. Denis, Rouen, and Lille in France.[6] By 1810 the manufacture of sulfuric acid was developed into a continuous process, and in 1823 the large-scale production of soda ash was started in Liverpool. Thus, the chemical industry acquired its first great tools, an acid and an alkali, each produced by scientific methods in definite strength and purity, in large quantities, and at reasonable cost.

Great Britain, the birthplace of the Factory System, was the first important market for industrial chemicals and the first country to produce them in large quantities. For years the Liverpool area, in the midst of a growing market and with nearby supplies of salt, limestone, and coal, remained the leading manufacturing center. Indeed, throughout the first three-quarters of the nineteenth century the British alkali industry was the largest chemical industry in the world,[7] such British exports as soda ash, bleaching powder, sal soda, caustic soda, Glauber's salts, and other chemical products becoming famous in many foreign lands.

In Germany important chemical developments began about 1865 with the organization and early growth of the dyestuffs and potash industries.[8] Following the conclusion of the Franco-Prussian War, Germany entered an era of peace and industrial expansion that was marked by unrivaled progress in chemical research and manufacturing. This progress had its roots in the German universities, which were the first to emphasize the teaching of physics and chemistry. So widespread was technical education in Germany that even minor executives and salesmen in the chemical industry were formally trained in chemistry. So superior was the quality of technical education offered by German universities that for decades many Americans and other foreign students went to Germany for advanced training. It was a large supply of trained brains that enabled Germany to make intensive use of such resources as coal,

[5] As textile manufacturing expanded abroad, the first lead-chamber sulfuric acid plants were established in France at Rouen in 1766, in the United States at Philadelphia in 1793, and in Germany at Potschappel near Dresden in 1820.—See Theodore J. Kreps, "Heavy Chemicals," *Encyclopaedia of the Social Sciences,* vol. 7, The Macmillan Co., New York, 1932, p. 301.

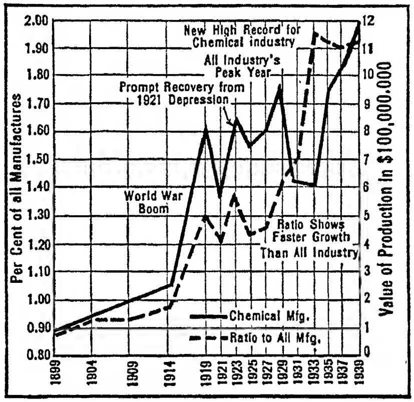
[6] Le Blanc's discovery was the first notable triumph in industrial synthesis. It marks the beginning of modern industrial chemistry and deserves to rank in importance with Watt's invention of the steam engine.—*Ibid.*

[7] Theodore J. Kreps, "Chemical Industries," *The Encyopaedia of the Social Sciences,* vol. 3, The Macmillan Co., New York, 1930, p. 365.

[8] *Ibid.*

potash, and salt and to find substitutes for so many of the things that she did not have. Among the triumphs of German chemical research were the successful production of dyestuffs from coal tar, atmospheric nitrogen, gasoline from coal, and a host of synthetic products including camphor and rubber. For years prior to World War I, the German chemical industry held an advantage in its large and highly trained personnel, a superiority that dwindled as education in the applied sciences became common in other countries. An Englishman employed in Germany made the key discovery in the coal tar dye series which finally produced literally thousands of dyes.

Ascendancy of the American Chemical Industry. While chemical manufacture grew rapidly in the United States after 1880, this country remained dependent upon imports, especially from Germany, for many important chemical products. World War I brought about a tremendous expansion of the American chemical industry (see Fig. 303), for the blockade of Germany and the reduction of imports from other European countries forced our market to depend upon domestic producers. Several thousand German patents were expropriated during the war and were made available to American manufacturers, who also received generous tariff protection to aid them in the postwar era. The United States emerged from the war with the world's largest chemical industry, supplying about 95% of the needs of the domestic market. As output increased and prices declined, our chemical industry soon developed an export trade second only to that of Germany.[9] Even during the business depression of the nineteen-thirties, American chemical production, measured either in tons or dollars, exceeded the combined output of Germany, Great



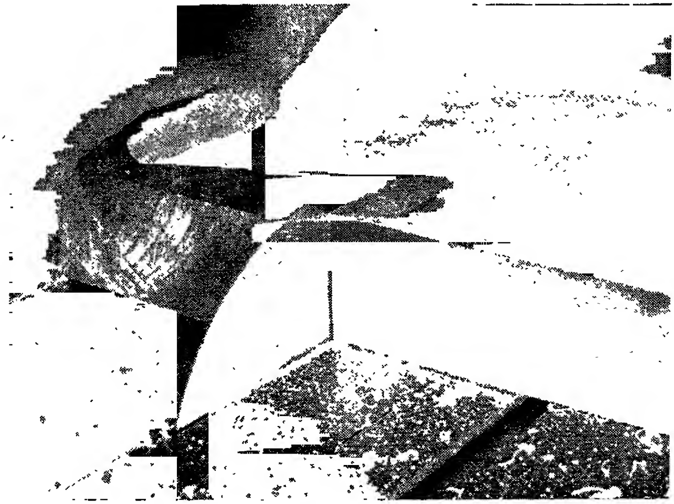
The remarkable growth of the chemical process industries opened the way for one to say that this is the age of chemistry and chemical manufactures.

Britain, France, Italy, Japan, and Russia.[10]

The American chemical industry has arisen upon a sound foundation. It possesses a large and increasing personnel of chemists, engineers, and technicians trained in American colleges and universities, it has access to a great wealth of raw materials and fuels, it serves a large and growing market capable of consuming thousands of products and by-products, and it is particularly fortu-

[9] In 1940 American exports of chemicals and related products were worth $221,900,000, as compared with $127,500,000 in 1938. In order of importance, these exports included industrial chemicals; chemical specialties; medicinal and pharmaceutical preparations; coal-tar products; pigments, paints, and varnishes; explosives, fuses, etc.; fertilizers and fertilizer materials; various sodium compounds; and soap and toilet preparations.—U. S. Dept. of Commerce, *Statistical Abstract of the United States, 1942*, Washington, 1943, pp. 620-625.

[10] Williams Haynes, *op. cit.*, p. 1.



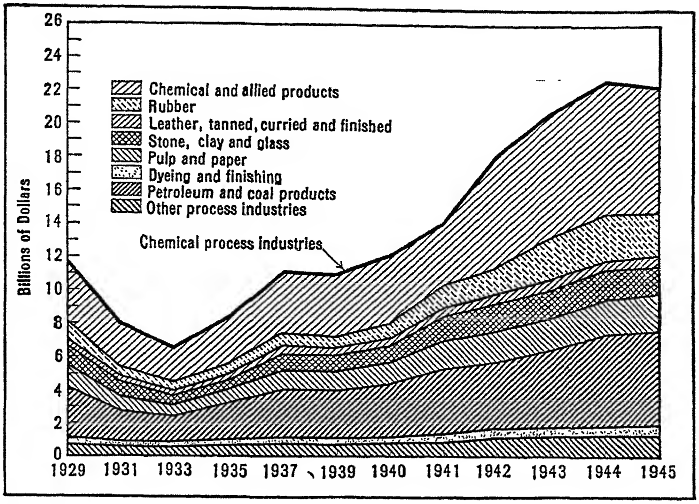
One of the many marvels of chemistry is to take strange liquids and turn them into solids, such as the plastic here being worked by the circular saw. Plastic products in almost myriad forms are advancing rapidly in the service of man.

nate in having access to tremendous capital funds. Each year large sums must be spent upon equipment that is subject to rapid depreciation and obsolescence.[11] Continuous and large-scale research is costly, and to an increasing degree it is being conducted in the laboratories of big manufacturing corporations and well-endowed universities and research foundations. In the last twenty-five years many eminent European scientists have been lured to this country not so much by fabulous salaries as by the splendid laboratory equipment with which they can work. In no other country is so much capital available for research, a powerful factor contributing to the phenomenal rise of our chemical industry.

The development of a truly great chemical industry in the United States reveals that this country is reaching industrial maturity. Not so many decades ago business enterprise in youthful America was confronted by a scarcity of capital and labor. It made only extensive use of raw materials as it skimmed the cream of our natural resources. Today business enterprise has an abundance of capital, labor, and technical skill which are profitably employed in making increasingly intensive use of raw materials through chemical research and manufacture.

Unfortunately the United States Government did not follow the example of its allies or its enemies, 1939-1945, and maintain the training of personnel for pure research. In 1945 there was much talk about this and the possibility that the government would heavily subsidize such training.

[11] Because of the wear and tear resulting from high temperatures, high pressures, and strong chemical actions and because of the frequent need for installing new types of equipment, manufacturers in some branches of the industry do not expect their equipment to last more than 2 or 3 years.



This graph giving the value of output of chemical process industries shows that in the slump of 1933 they declined much less than most other industries and expanded much more during the war years.

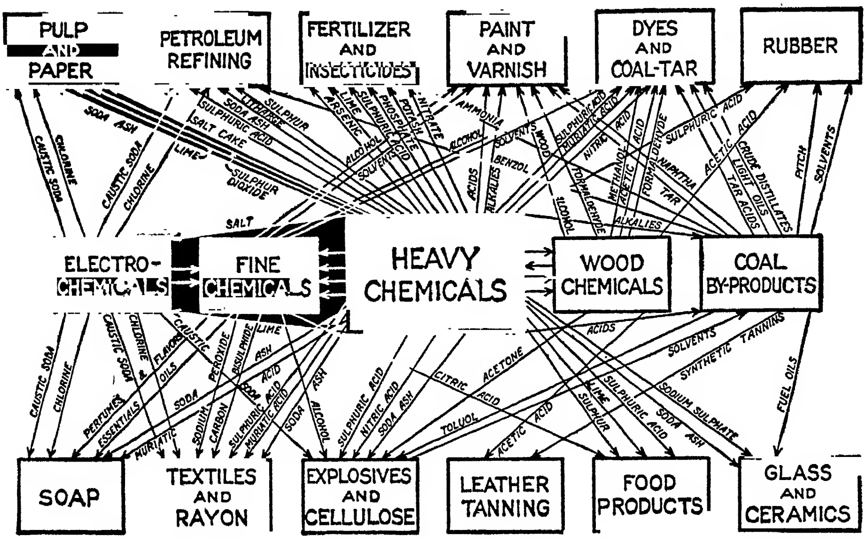
3. The Raw Materials

Primary Raw Materials. Countless products of the land, sea, and air come under the scrutiny of the chemist in his laboratory as he pursues his research, ever fusing, distilling, and extracting new substances of use to mankind.[12] While a multitude of organic and inorganic materials, gathered from the far ends of the earth, are now used in the chemical industry, only a few are of outstanding importance. In addition to such ubiquities as air and water, the principal primary raw materials are sulfur, salt, limestone, coal, petroleum, potash, phosphate, nitrate, and, more recently, such sources of cellulose as wood and cotton. These primary materials and others of growing importance are used in the production of secondary raw materials, particularly the great acids and alkalies, which in turn are employed in the manufacture of a host of chemicals and other products. Seldom does the first or even the second step in chemical manufacture result in a product that is familiar to a person without technical training or that is of direct use to the average man (see Figs. 306 and 308). Almost inevitably many steps in production must occur between the first use of a primary raw material in the chemical industry and its ultimate consumption in the form of a finished product.

Sulfuric Acid. Greatest of all acids and unquestionably the most important manufactured material used by the chemical industry is sulfuric acid, which is often referred to as a chemical barometer.[13] The increase in output of sulfuric acid in the United States from 425,000 tons in 1880 to 3,539,000 tons in

[12] From the 92 fixed elements (sulfur, sodium, calcium, carbon, oxygen, hydrogen, etc.) that are known to exist, hundreds of thousands of compounds have been created in the laboratory. Many of these were never produced by nature; some, such as vanillin, the flavor of vanilla, were.

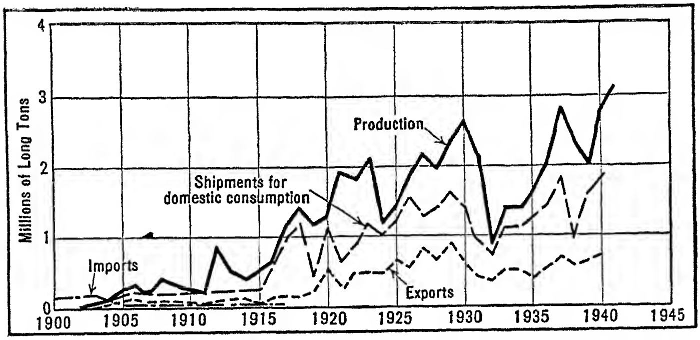
[13] Other acids of great industrial importance are hydrochloric (muriatic), acetic, and nitric.



Why does not Costa Rica, Peru, or New Zealand have an elaborate industrial equipment? This graph shows the interlocking service that each of scores of industries renders to others and illustrates the difficulty in developing complicated industry in a country with a small market, even if it has political stability and justice.

1913, and to about 12,000,000 tons in 1942 strikingly reveals the phenomenal growth of our chemical industry. Indeed, some persons even go so far as to say that one can gauge the civilization of a people by the amount of sulfuric acid they use, but, of course, "civilization" has many diverse definitions. We venture to state that it pertains to living and is primarily spiritual, not technological. The United States leads in sulfuric acid manufacture with about one-third of the world's total output, other important producers including Japan, Germany, Russia, Great Britain, France, and Italy. In this country about two-thirds of all sulfuric acid is normally consumed in fertilizer factories, petroleum refineries, chemical works, and iron and steel plants, the remainder being used in the manufacture of coal products, various metals, pigments and paints, rayon and other textiles, and many miscellaneous products.

Sulfuric acid is made by roasting either pyrites or native sulfur, the resulting sulfur dioxide gas being converted into sulfur trioxide that unites with water to form acid. By the use of modern lead-chamber and direct contact processes, the acid is produced at a cost of less than a cent per pound. Most of the world's sulfur is derived from iron and cupreous pyrites, sulfides that are mined chiefly in Spain, Japan, Norway, Russia, Italy, Cyprus, and Portugal. For years the island of Sicily held a virtual monopoly in the production of native sulfur, which is dug from volcanic deposits with much manual labor. The United States was long dependent upon Spain and Sicily for its supply of sulfur, and it was not until the perfection of the Frasch process in the early years of this century that our large deposits of native



Sulfur in the United States—production, consumption, and exports. It apparently is another industrial barometer, another place where modern society has given hostages to the mineral world.

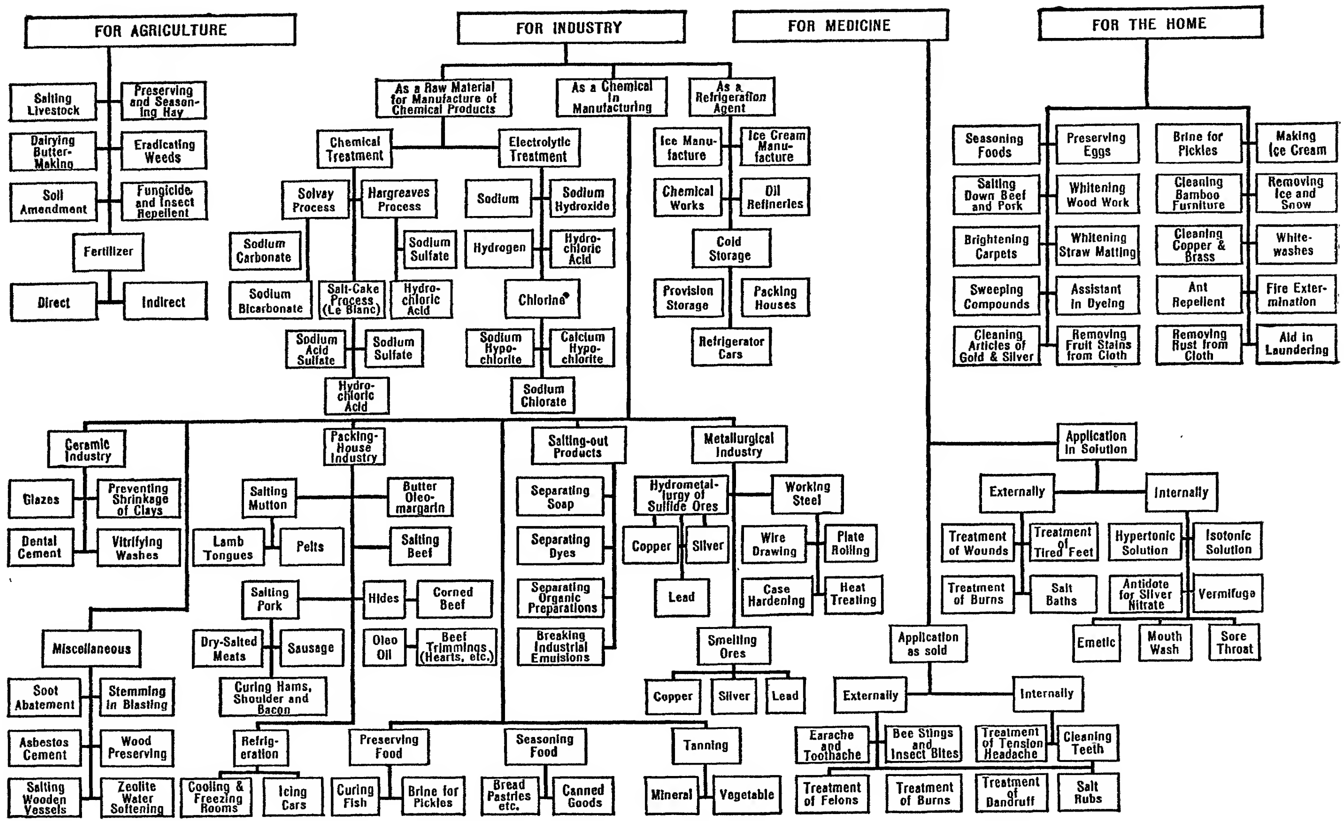
sulfur along the Gulf Coast of Louisiana and Texas became available for commercial production.[14] By this unique process water heated to about 300° F. is pumped down into the sulfur beds, and compressed air is forced down through a second pipe, which forces the molten sulfur (over 99% pure) up through a third pipe to the surface of the earth, where it flows into bins and solidifies. As a result of the development of this process, the United States became the world's largest producer and a great exporter of sulfur.

The treatment of copper and zinc ores yields important quantities of sulfur, which is recovered at the mills as pyrites concentrates or at the smelters as sulfuric acid.[15] Copper mining companies at Ducktown, Tenn., and Anaconda, Mont., are among the largest producers of sulfuric acid in this country, and they are able to use a noisome gas that formerly destroyed the vegetation for miles around. Some by-product sulfur is also recovered from coke-oven gas, petroleum-refinery gas, and natural gas.

Soda Ash. Almost equally important with sulfuric acid as a chemical raw material is soda ash, or sodium carbonate, used in manufacturing of glass, chemicals, soap, and paper, and in the refining of petroleum. It is chiefly made by the Solvay process, a Belgian invention that has done much to cheapen alkalies. The sodium in the soda ash is furnished by common salt, in the form of brine secured either from salt springs or by the easy method of pumping water down through the earth to the salt beds through one pipe and pumping it out by another after it has done the work of the miner by dissolving the salt hundreds of feet below. Coal, coke, and limestone are also used in the process of manufacture; and the plants are usually located where salt and limestone both exist. In this country the chief soda works are at Syracuse, N. Y., Detroit, Mich., Baton Rouge and Lake Charles, La., Saltville, Va., and Barberton, Ohio. Small amounts of soda ash are obtained

[14] For the interesting story of the development of the American sulfur industry, see Williams Haynes, *The Stone that Burns,* D. Van Nostrand Co., Inc., New York, 1942.

[15] Of 11,040,000 tons of sulfuric acid consumed in the United States in 1941, 916,000 tons were by-products of copper and zinc mining.



Common salt is shown by this diagram to have more uses than many would suspect and when it becomes one of the bases of soda ash, which in turn is one of the base materials of the chemical industries, its services become almost beyond enumeration.

from the brines of Owens and Searles Lakes in southern California and also as a by-product from the electrolytic manufacture of caustic soda. Since World War I the United States has become an exporter of soda ash, and our annual output of 2 to 3 million tons is more than twice that of Great Britain, Germany, or Russia.

Caustic soda and chlorine are important alkalies which like soda ash are dependent upon salt as a primary raw material. Most caustic soda in this country is used in the rayon, soap, chemical, petroleum, and paper industries, while chlorine is widely used as a bleach for textiles, in water purification and sewage disposal, and in the production of dyestuffs and explosives.

4. The Manufacture of Explosives

Explosives have long been the most spectacular of the chemists' products. Long used for destruction only, they have at last entered industry, and are performing rapidly increasing services, since dynamite has become cheap. Without dynamite and gunpowder the prosecution of the mining and quarrying industries, and the building of our railways, tunnels, subways, and canals would be impossible. Our per capita consumption of explosives amounts to nearly 4 pounds per year, and in 1910 we shipped over 10,000,000 pounds for use in the Panama Canal. The danger and consequent cost of transport is the dominating factor which scatters the centers of manufacture, as high freights scatter cement plants. The assembling of the raw materials is much easier than the handling of the finished explosives, but it is a distinct advantage to have the plants on tidewater. The Delaware River has long been the greatest location for the manufacture of explosives, with the center at Wilmington, Delaware. The great danger of explosives causes the plants to be removed from city limits to isolated locations often in or on the edge of swamps.

The god of war has developed a Gargantuan appetite for many materials as well as for men, and it now costs several thousand dollars to kill a single soldier in battle as compared with only 24 cents in the time of Julius Caesar.[16] As late as our Civil War the ingredients of warfare were simple, namely, charcoal, sulfur, and saltpeter that were used in making cheap black gunpowder. Modern warfare makes extensive use of high explosives that are obtained from combinations of many materials. Thus, cotton and wood yield cellulose, vital in the production of nitrocellulose and smokeless powder. Various fats and oils are employed in the manufacture of nitroglycerine and dynamite. Acetone derived from the fermentation of corn and common grain alcohol are needed to make smokeless powder. Petroleum refineries and coke ovens yield toluene, basic material in trinitrotoluene and amatol, and benzine for the production of tetryl, trinitrotoluene, and picric acid. Nitrogen is derived from the air, the coke oven, and natural deposits of sodium nitrate. It is made into nitric acid, which is generally mixed with sulfuric

[16] Harry N. Holmes, *Strategic Materials and National Strength,* The Macmillan Co., New York, 1942, p. 47.

acid and is indispensable to the manufacture of almost every high explosive.

Most of our chemical industries are capable of considerable expansion in time of necessity.

5. *Essential Oils*

"Essential oil" is the name applied to oils that are characteristic of particular plants. Thus the cinnamon flavor is in the essential oil which can be entirely extracted from the cinnamon bark. Essential oils enter largely into drugs, medicines, perfumes, and flavors. The extraction is sometimes by distillation, sometimes by other processes. The production of these oils is a combination of agriculture and chemical manufacture—agriculture furnishing the raw material. Orange, lemon, and bergamot oil are citrus products made chiefly in Sicily and Calabria, where the fruits are cheap and labor abundant. Lime oil comes from Montserrat and other West Indian islands.

India exports a number of seeds producing essential oils, and China ships, largely through Hongkong, about 600,000 pounds a year of aniseed and cassia oils.

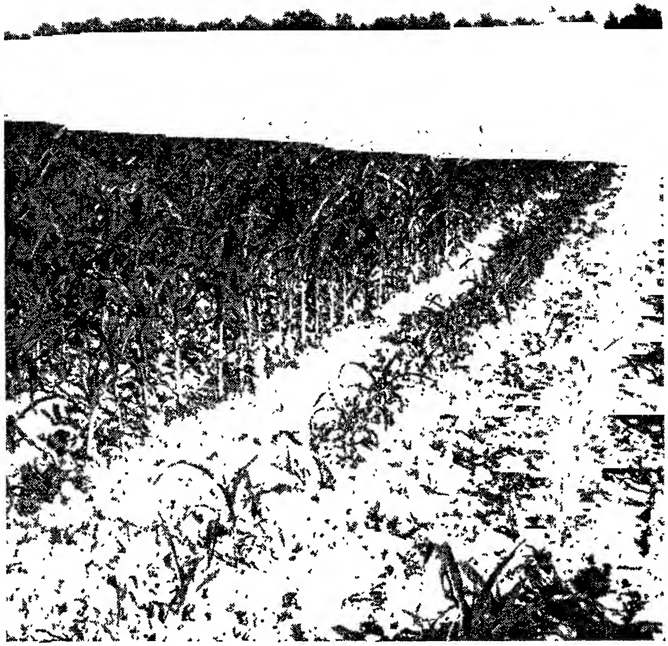
Another class of these oils appears in perfumery. The growers of Damascus roses in Bulgaria give to the western world its chief supply of the precious attar of roses. Its costliness results from the fact that to make one pound of attar of roses requires 2 to 3 tons of roses.

The principal perfume center of the world lies between the Bay of Cannes and the mountains beyond Grasse in southern France, though flowers for perfume come from every country and climate. The flower farms in Alpine villages are the mecca of lovers of perfume. From December until March fragrance is extracted from various herbs; in March work begins on fresh flowers, including the violet, and then the jonquil, orange blossom, rose, mignonette, jasmine, tuberose and cassie buds.

Essential oils are merely one class of chemicals and drugs. There are also numerous vegetable extracts other than oils, such for example as nux vomica and strychnine, the products of a bean yielded by a tree growing wild in the forests of India. The few oils and extracts mentioned here are suggestive of the rapidly widening use of a class of products in which discovery has but begun, and in which cultivation and manufacture follow on the heels of demand made effective by new laboratory processes.

6. *The Fertilizer Industry*

One of the greatest of all chemical industries is that devoted to the production of chemical plant foods known as fertilizers. Of the several important chemicals necessary to the growth of plants, three—namely, phosphorus, potassium, and nitrogen—often exist in the soil in insufficient amounts or in unavailable forms, and must be supplied if prolific crops are desired. These three substances in many different forms and commodities are the main raw materials of the fertilizer manufacturer, and he ransacks the world to get them. We are now learning that a number of minor elements are of unexpected value. A few pounds of boron to an acre will make three tons of rank green alfalfa grow where but one or two tons of sickly pale product grew before.



The stalks of corn in the pigmy row are about 7 inches high; those in the row to the left are 40 inches high—cause: two fertilizer outlets in a drill got stopped up. The fertilized corn will make something—the unfertilized corn will make nothing except perhaps a little rabbit food. A good example of the dependence of agriculture in some parts of our country on fertilizers. Without them, many of our sections remained virtually unsettled for 200 years, while at the same time, the heavy and more fertile soils a few miles away were populous generation after generation. It may also be pointed out that the chemical fertilizer permits farming to continue where the land would otherwise have been allowed to grow up in wood and stop erosion. A fairly strong case could be made that fertilizer by its misuse has contributed greatly to soil destruction by making it possible for stupid farmers to continue after the native fertility was temporarily exhausted.

Guano. The first article extensively used as a commercial plant food was guano, the excrement and dead bodies of sea birds which have lived and nested in places where the rainfall is insufficient to dissolve and carry away the deposits. Of all the accumulations of valuables upon the surface of the earth, none have been more productive of easily gathered wealth than the guano beds of the rocky Chincha Islands off the desert coast of Peru, where for unknown ages myriads of sea birds had lived and nested. Upon the discovery of the value of guano, these islands became a mine rich with the newest fossil accumulations, and yielding between 1840 and 1880 about $600,000,000 worth of valuable plant food (nitrogen and phosphorus) which was chiefly taken around Cape Horn to Europe and America, and sold at from $30 to $60

per ton. As the taxation of this industry was most easy, it was for a long time the support of the Peruvian Government. The danger of exhaustion brought about the establishment in 1909 of rigid control of output, which in recent years has varied between 75,000 and 160,000 tons a year, most of which is used to fertilize the irrigated lands of coastal Peru.[17]

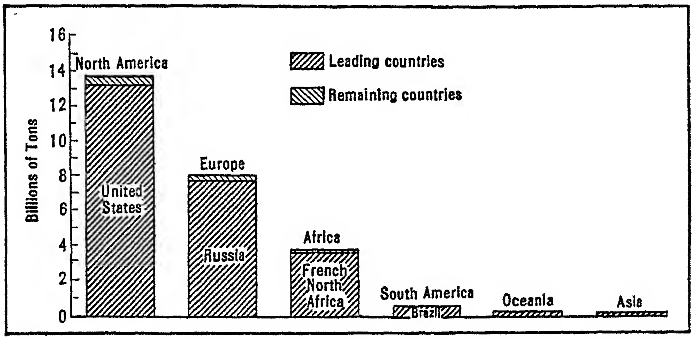
Small amounts of guano are still exported from the west coast of South America and from some of the drier West Indian and other tropic islands, but its place as a fertilizer has, since 1880, been quite largely filled by chemicals from widely different sources.

Bones. The bulkiest, cheapest, and possibly the most important of these rival plant foods are phosphates, which furnish phosphorus to the plants. Much of the phosphorus of the world has been concentrated as phosphates in the bones of animals. Consequently, it is from animal sources, directly or in fossil form, that nearly all available phosphorus is obtained. Thus, ground bone is an important fertilizer, and for many years the bone hunters, with their wagons, roamed the western plains of the United States, getting these last remnants of the buffalo and cattle that had perished in blizzards, by the wolf pack, or by the hand of the hunter. Shiploads of bleached bones were picked up on the plains of Argentina and shipped to the fertilizer plants of the eastern United States and Europe. Today the great slaughterhouse of the large city and the small butcher of the village both furnish their contribution.

Fossil Phosphates. By far the greatest amount of phosphorus is now obtained by man from the fossil remains of animal life, known as phosphate rock, from which, by chemical process, fertilizers are made.

No other country approaches the United States in phosphate rock reserves (see Fig. 313). The lime phosphate rock in the southeastern states is usually found so near the surface that it can be mined by hydraulic or open-pit methods. This industry started near Charleston, S. C., but since 1887 most of the nation's phosphate has come from deposits along the west side of the Florida Peninsula near Tampa. Of our total output of 4,688,000 tons in 1941, 72% was mined in Florida, 24% in Tennessee, and about 4% in the West. The phosphate deposits of Montana, Idaho, Utah, and Wyoming are the most extensive yet discovered, and estimated to contain 13 billion tons of high-grade rock. While these western deposits are much larger and purer than those of the Southeast, their development has been retarded by remoteness from the market and by the fact that shaft mining is necessary and costly, but these western deposits constitute one of our great reserves for the high-priced future. In addition to supplying the American market, we export nearly a million tons a year, chiefly to Japan, Germany, Canada, Holland, and Great Britain, shipments being made chiefly through the

[17] The cold waters of the northward-flowing Peruvian Current are rich in minute organisms that support a great abundance of fish, which are eaten by the birds. An Associated Press dispatch of May 21, 1941, reported the starvation of huge number of the "guanay birds" caused by a temporary shift in ocean currents which destroyed much of the birds' normal supply of feed. In 1943 the Guano Administration, a quasi-governmental agency, permitted the removal of only 63,000 tons of guano. Modern Peru is merely copying what the Incas did.



The phosphate rock reserves of the world serve to emphasize the poverty of Asia and once again the relatively unbelievable riches of the United States of America. We are a lucky people.

ports of Tampa and Fernandina which are well equipped with modern loading machinery.

In Russia, which ranks second only to the United States in reserves and production,[18] phosphate rock is mined at Khibini on the Kola Peninsula, between the Volga and Dnieper Rivers, and at Aktyubinsk in northern Kazakstan. Nearly all of the output is consumed in Russia, although considerable quantities at times are exported to west central Europe.

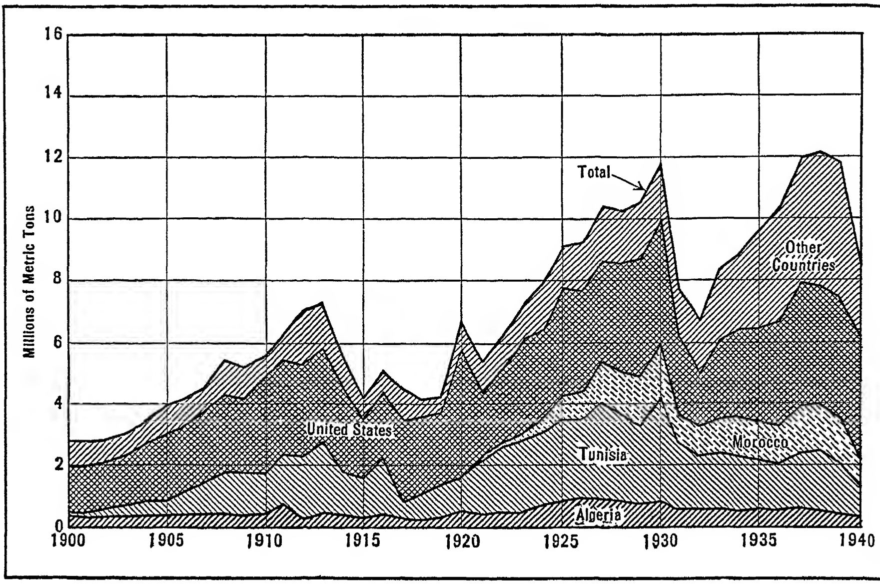
The French colonies of Tunisia and Morocco are the world's greatest exporters of phosphate and normally supply 50% to 80% of the requirements of Europe. The phosphate of these two countries is of greater purity than that of Florida and lies nearer to the European market, it occurs near the surface and is easily worked by open-pit or adit methods and with cheap Arab labor, and it must be exported if it is to be sold at all since the domestic market is negligible. Gafsa, Tunisia, and Kourigha, Morocco, are the leading mining centers.[19]

While phosphate rock is sometimes ground and applied directly to the soil, this method of fertilization is not very effective. The phosphorus in phosphate rock usually enters fertilizer mixtures in the form of phosphoric acid, which is made by treating the rock with sulfuric acid, the resulting product being known as acid phosphate or superphosphate. The great bulk of all phosphorus today is used in fertilizer, but in various forms phosphorus also enters into the production of matches, bullets, baking powder, boiler compounds, dyestuffs, pharmaceuticals, jellies, soft drinks, and stock and poultry feed.

For some years increasing amounts of phosphorus have been derived from the basic Bessemer and basic open-hearth processes of iron and steel manufacture.

[18] In 1938 six countries produced three-fourths of the world's phosphate, their output in terms of tricalcium phosphate content being as follows: United States—2,833,000 tons, Russia—1,494,000 tons, Tunisia—1,189,000 tons, Morocco—1,144,000 tons, Germany—964,000 tons, and Nauru Island—654,000 tons. (These data include basic slag and other sources of phosphorus.)—Charles K. Leith, James W. Furness, and Cleona Lewis, *World Minerals and World Peace,* The Brookings Institution, Washington, 1943, p. 36.

[19] Phosphate rock is also mined at Tebessa, Algeria, and along the Egyptian coast of the Red Sea. Japan and Australia obtain much phosphate from Nauru, Ocean, Makatea, and Christmas islands.



The world production of phosphate rock shows our growing dependence upon this maker of bones, and with Algeria, Tunis and Morocco well in the running, it shows the importance of North Africa. During both World Wars the cutting off of the African supplies from Germany helped to reduce her food supply. (1939 and 1940 estimated.)

The limestone linings of the furnace draw the phosphorus from the molten iron and steel, and are later ground up and sold under the name of basic slag, or Thomas meal, quite largely used as fertilizer in Europe. About 90% of the world's basic slag is produced in Germany, France, Belgium, and Luxemburg,[20] where phosphatic iron ores are of outstanding importance in steel-making and where long-used farm lands require much fertilizer, yet each of these countries depends largely upon imports of phosphate rock. The United States, rich in fossil phosphates, makes little use of basic slag, about 25,000 to 50,000 tons being produced each year by the steel mills of Birmingham, Ala.

Potash. The second great raw material in the fertilizer industry is potash, which is also used in the manufacture of soap, glass, munitions, high-octane gasoline, drugs, photographic materials, and other products. Although potash may be derived from wood ashes, kelp, blast furnace and cement plant dust, sea water, lake brines, playa deposits, and such potash-bearing rocks as alunite and feldspar, these sources are normally unimportant in comparison with the large and cheap supply derived from a few great deposits of potash salts. For years prior to World War I, the whole world depended upon the mines of Stassfurt, near the Elbe River, in Germany, where potassium salts are associated with a large deposit of common salt.

Through ownership of the huge deposits at Stassfurt and smaller but important deposits along the upper Rhine

[20] The world's output of basic slag fluctuates between 4 and 6 million tons a year, European slag varying from 14% to 22% in phosphoric content.

in Alsace,[21] Germany held a monopoly in potash production for decades prior to World War I. All mining companies belonged to a powerful cartel, or syndicate, that controlled output, exports, and prices.[22] This cartel consistently followed a policy of charging a higher price on exports than on domestic sales, thus favoring German consumers. With the return of Alsace to France at the end of the war, competition developed between German and French producers, but this was eliminated in 1924 when France joined the cartel in an agreement regarding prices and the partition of markets. Poland, with newly developed deposits in the Carpathian section of Galicia, joined the cartel in 1932. As potash deposits were subsequently developed near Cardona in northeastern Spain, in the western Urals at Solimansk in Russia, and in Palestine, these countries were also brought within the price and market control of the cartel.

Fortunately for the United States, which suffered from a shortage of potash caused by the curtailment of imports during World War I, the coordinated effort of our federal government and private enterprise finally resulted in the discovery and successful exploitation of valuable potash deposits in an area of about 40,000 square miles east of Carlsbad, N. M., that extends into western Texas. These deposits may contain 300,000,000 tons of potash salts, the proved reserves of New Mexico alone amounting to more than 100,000,000 tons, one-fourth of which is twice as pure as the excellent potash at Stassfurt, Germany. Commercial production got under way in 1931, and by 1938 this country ranked second only to Germany and France in output.[23] In 1941 about 82% of our potash supply was mined in the Carlsbad area, the remainder being derived chiefly from the brines of lakes in the West. While the Carlsbad deposits have the disadvantage of a 400-mile rail haul to Gulf ports, it is clear that we have achieved potash independence of Europe, and in 1942 potash prices in this country were actually lower than in 1913.

Sources of Nitrogen. The third great fertilizing material is nitrogen, which in various forms provides vital food for plants and sustenance for human life. Paradoxically, in the form of nitric acid as an ingredient of munitions and explosives, it is also one of the most powerful agents in human destruction.[24] In contrast with potassium and phosphorus, which are obtained primarily from exhaustible mineral deposits, nitrogen has unlimited possibilities of output since it is now derived economically from the air. About 75.5% of each cubic foot of air by weight is pure nitrogen gas, approximately 22,000,000 tons of it resting upon each square mile of the earth's surface, yet this limitless supply

[21] Mining in Alsace did not begin until 1910 and did not yield more than 5% of the German output in prewar years.

[22] See Charles K. Leith, James W. Furness, and Cleona Lewis, *op. cit.*, pp. 114-118.

[23] In 1938 potash production, in terms of potassium oxide content, was as follows: Germany—1,861,000 tons, France—582,000 tons, United States—288,000 tons, Russia—266,000 tons, Poland—106,000 tons, all others—54,000 tons.—*Ibid.*, p. 36.

[24] About 85% to 90% of all chemical (inorganic) nitrogen is normally consumed as fertilizer, the remainder being used for such industrial purposes as refrigeration, water supply treatment, and the manufacture of nitric, sulfuric, and other acids, various alkalies, rayon, nylon, rubber, plastics, and other products.—U. S. Tariff Commission, *Chemical Nitrogen*, Report No. 114, Second Series, Washington, 1937, pp. 8-9, 19-30.

remained only a potential resource as late as 1900 because the problems of extracting nitrogen from the air and combining it with other elements had not been solved. In 1900 two-thirds of the world's supply of inorganic nitrogen was obtained from deposits of *caliche,* or natural sodium nitrate, in northern Chile, the remainder being derived as a by-product of coal.[25] Today, as a result of the perfection of various nitrogen fixation processes, more than three-fourths of the supply is atmospheric nitrogen, while less than a fifth is a by-product of coal, and only about 5% comes from the mines of Chile. Thus, in a remarkably short time science has wrought a great revolution in the relative importance of the leading sources of nitrogen.[26]

This chemical revolution was hard on Chile which once got most of its revenues from the export tax on nitrate in the good old days when that country had a virtual monopoly, as Peru once had on guano. All animal matter is more or less nitrogenous and for centuries the Chinese and Japanese have collected animal and human excrement, carefully applying it to the soil. Wherever available, animal manure is commonly used on farm lands today. Fertilizer is also made from blood, bones, and other slaughterhouse waste, from fish scrap, and from the cake or meal that remains after oil has been extracted from soybeans, cottonseed, and peanuts, but such materials comprise only about 15% of the world's total manufactured nitrogenous production.[27] It is from inorganic materials, however, that the modern fertilizer industry derives the great bulk of its nitrogen supply, and for decades prior to 1921 the greatest of these materials was the natural sodium nitrate of Chile.

Natural Sodium Nitrate. Deposits of natural sodium nitrate occur only in deserts, where nitrate and other salts have crystallized out of rising and evaporating ground waters and have been preserved by extreme aridity. Some nitrate is found in the deserts of northern India, Egypt, southern California, and Nevada, but the supply of the nitrate in commercial quantities is a monopoly of the Desert of Atacama in northern Chile.

The Chilean deposits are scattered irregularly throughout a zone about 450 miles long that extends from 19° to 26° S. Lat. and that lies between the low coastal range and the Andes at an elevation varying from 4,000 to 7,000 feet above sea level. The *caliche,* or nitrate-bearing stratum, varies in thickness from a few inches to 10 feet or more, it varies in nitrogen content from a mere trace to as much as 60%, and it may be found at the surface of the earth or 25 feet below. So firmly does the nitrate cement the rock material with which it is associated that much blasting is usually necessary. The material is scooped up by giant electric shovels and is carried by narrow-gauge railroads to the *oficina,* or nitrate-treatment plant, where it is crushed by huge machines that handle as much as 16,000 tons a day. The crushed material is dumped

[25] U. S. Tariff Commission, *Chemical Nitrogen,* Report No. 114, Second Series, Washington, 1937, pp. 2, 60.

[26] See *ibid.,* pp. 1-17, 31-52; Ray H. Whitbeck, "Chilean Nitrate and the Nitrogen Revolution," *Econ. Geog.,* vol. 7, July, 1931, pp. 273-283; and "Nitrogen: Competion or Not?," *Fortune,* vol. 29 February, 1944, pp. 129-130 ff.

[27] U. S. Tariff Commission, *op. cit.,* p. 1.

into great vats and is dissolved by boiling water, the solution being sent to cooling vats where the nitrate is precipitated and the water is drawn off to be used again. The nitrate is piled on cement floors where it dries rapidly in the desert air. As a result of improvements in the nitrate-treatment process, the recovery of nitrate has been increased from 60% to as much as 90%.[28] From the *oficina* nitrate is shipped in 200-pound bags to Antofagasta, Mejillones, Tocopilla, Iquique, and other coastal towns for export.

In this barren desert everything except rock, sand, and gravel must be imported from afar—men, food, water, animals, feed, machinery, fuel, structural steel, timbers, nitrate bags—literally everything needed to support the thousands of workers who make their daily living by extracting from the desert the nitrate accumulations of the past. Most deserts support some vegetation, but in the dry Atacama are large areas with no vegetation at all.[29] Fresh water must be piped to the *oficinas* from Andean streams more than 100 miles away; Antofagasta, the leading nitrate port, is served by a pipe line 230 miles long. Some food and feed is obtained from irrigated oases in the Peruvian province of Tacna to the north and from oases at Copiapó and Vallenar to the south, but most of the food and feed supply must be imported hundreds of miles from the farms of central Chile. Much of the meat supply arrives on the hoof, herds of cattle being driven all the way from Salta and Jujuy in northern Argentina through Andean passes 15,000 feet high and across the desert sometimes for days without feed or water. The people of Antofagasta (pop. 54,000), Iquique (pop. 47,000), and other coastal towns make their living not only from handling nitrate exports but also from the indispensable import trade.

From 1880 to 1930 the Chilean government levied a tax of about $12 a ton on all exports of nitrate, which increased from 200,000 tons in 1880 to more than 1,000,000 tons a year after 1894, and reached peaks of about 3,000,000 tons in 1916-18, in 1920, and again in 1929. For half a century a golden stream poured into the federal treasury from the export tax on nitrate, averaging $25,000,000 a year. In some years the revenue amounted to 80% of the government's total income, and in most years it was more than half. Probably no government in modern times was so completely dependent upon the prosperity of a single industry as was the Republic of Chile. Not only was nitrate a prolific source of governmental income, but it provided employment for 40,000 to 60,000 workers in the nitrate fields, profits for Chilean and foreign capitalists, a market in the desert for the farm products of central Chile, and a supply of foreign exchange to pay for imported manufactures.[30]

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28 Ray H. Whitbeck, *op. cit.*, p. 280.

29 Between 1899 and 1919 fourteen years passed at Iquique without a drop of rain, and during the six years when some rainfall occurred the total amount was only 1.1 inches. At Calama no rainfall has ever been recorded.

30 Not least among the effects of easy income from nitrate was the fact that the wealthy landlords of central Chile paid very small taxes as well as low wages and were able to maintain their semi-feudal estates at a profit. Less than 600 families own 60% of all arable land in Chile, and they have bitterly resisted property taxes and social reform.—See George M. McBride, *Chile: Land and Society*, American Geographical Society, New York, 1936, and "South America III: Chile," *Fortune*, vol. 17, May, 1938, pp. 74-83 ff.

When the nitrate *oficinas* were busy, Chile prospered, but unfortunately the American and European demand was at times erratic. In 1921, a bad year in the nitrate trade, the government was overthrown and was unable to pay the interest on its bonds. The years 1926 and 1927 were bad years, and in 1928 Chile witnessed nine changes in government, two general strikes, a mutiny in the navy, various uprisings, suppression of newspapers, and the arrest and exile of many prominent persons. With the growth of competition from by-product and atmospheric nitrogen, the Chilean nitrate industry finally collapsed in the midst of the world's greatest business depression, exports in 1932 amounting to only 260,000 tons. In 1934 the industry was brought under governmental control, but the government has been forced to make agreements with a European cartel, which controlled about 70% of the world's total nitrogen production and which determined how much Chilean nitrate should be sold abroad and where. In 1938 only 25 out of 152 *oficinas* were in operation, with exports amounting to 1,548,000 tons. Of all nitrogen consumed as fertilizer in the United States in 1940, only 20% was imported Chilean nitrate. It is clear that Chile's once powerful nitrate industry faces a very uncertain future.

Chilean *caliche* contains the valuable drug iodine, which is recovered as a by-product of the nitrate-treatment process. Only a small portion of the quantity that might be obtained is actually recovered, for the total quantity available could not be sold. Chile normally produces about 70% of the world's supply of iodine, but it has lost the American market; for we now obtain our iodine as a by-product from the refining of Californian petroleum. Poor Chile!

Nitrogen from Coal. At the very time when large-scale production of Chilean nitrate was getting under way, competition began to appear. About 1880 Germany, France, and Belgium began to replace their beehive coke ovens with by-product ovens that collected the gases that formerly went to waste. One of these gases is ammonia, which in pure form is 82% nitrogen. When ammonia is passed through sulfuric acid, it is converted into ammonium sulfate, an excellent fertilizer material. Since ammonium sulfate is only one among a great many products derived from the coke oven, it can be sold at a very low price, but the output, of course, is limited by the extent of coke oven activity. Ammonium sulfate is also obtained as a by-product of the manufacture of artificial gas from coal. More than two-thirds of all by-product nitrogen is made in the United States, Germany, and Great Britain, great industrial nations that are important producers of coke and artificial gas.

Atmospheric Nitrogen. Greatest of all nitrogen sources today is the inexhaustible atmosphere, the production of nitrogen from air amounting to more than three times the combined output from coal and *caliche*. About 1900 two processes were perfected that solved the problem of extracting nitrogen from the air, both being dependent upon very cheap electric power. By one method, known as the arc method, heated air is passed through a huge electric arc, the oxygen and nitrogen of the air combining to form oxides, which are subsequently absorbed in water to make nitric acid. This process was developed

in Norway, a land blessed with cheap hydro-electric power, where it was used for 24 years. Because of its large power requirements, the arc process was adopted in very few countries and is obsolete today.

A second process, developed in Germany about 1900, involves the use of coke and limestone in electric furnaces to make calcium carbide, which is then treated with nitrogen gas under slight pressure at a temperature of 2,120° F. to form calcium cyanamide that can be treated with water and steam under pressure to make ammonia. This process was widely developed in Europe and proved of great aid to blockaded Germany during World War I. One large cyanamide plant was erected in 1909 at Niagara Falls, Ontario, and continues in operation today, but a plant built by our government at Muscle Shoals, Ala., was never used commercially because of political opposition. The chief handicap to this process is the large amount of power needed to make calcium carbide, and the cyanamide process now yields only about one-tenth of the world's inorganic nitrogen supply.

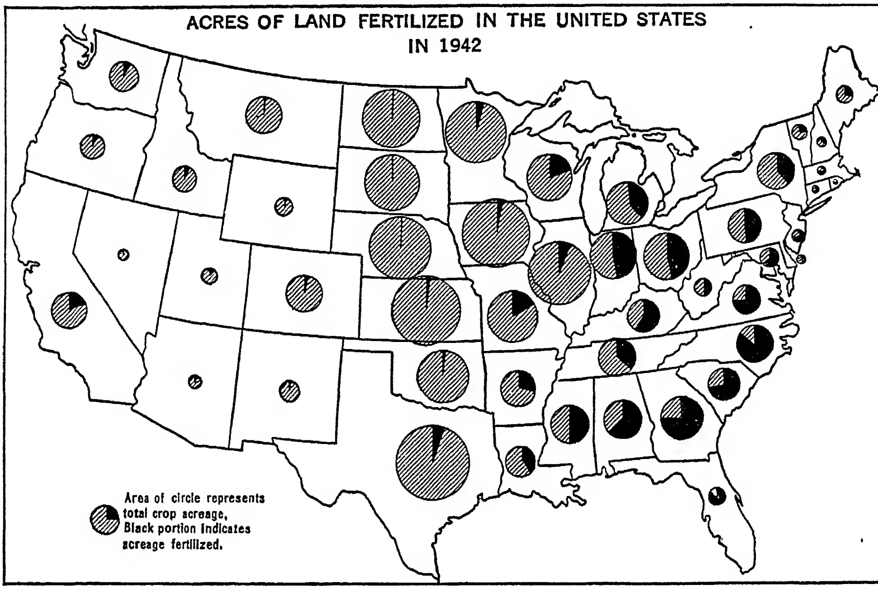
By far the most important method for the fixation of nitrogen from the air is the Haber-Bosch process of producing synthetic ammonia that was perfected in Germany in 1913 in time to help supply that nation with ample nitric acid during the ensuing four years of war.[31] The success of this process was largely the result of newly developed chemical knowledge of catalysts.[32] In the Haber-Bosch process pure hydrogen from water gas and pure nitrogen from producer gas are combined under great pressure at a temperature of 1,022° F. in the presence of small amounts of iron and other oxides. The nitrogen comes from the air, for producer gas is made cheaply by passing a mixture of air and steam through an incandescent bed of coke, anthracite, low volatile non-coking coal, or even lignite. The hydrogen is usually derived from water gas made by passing steam through incandescent coke or other fuel, but it is being obtained increasingly from coke oven gas, from the electrolysis of water and brines, and more recently from natural gas.[33] The Haber-Bosch process has much smaller power requirements than other nitrogen fixation processes, and its energy supply does not have to be electrical. This process, or various modifications of it, accounts for more than two-thirds of the world's output of inorganic nitrogen.

As a result of increasing production of nitrogen from the air and from coal, the leading industrial countries of northwestern Europe are self-sufficient in nitrogen and have a surplus of nitrogenous products for export. In 1913 the United States produced only 39,000 tons of inorganic nitrogen, which was entirely the by-product of coke ovens and gas plants. Not until 1926 was the first commercial nitrogen fixation plant opened at Hopewell, Va., a second plant

[31] It has been pointed out that Germany did not start this war until she had this nitrogen supply in sight.

[32] A catalyst is a substance that by its mere presence causes the union of two other substances that might otherwise remain separate. Thus, finely divided nickel is used in the hydrogenation of petroleum. Like the minister at a wedding ceremony, the catalyst is momentarily involved in performing an important service.—See Edwin E. Slosson, *op. cit.*, pp. 28, 208.

[33] In 1944 five plants in the United States using natural gas had a total capacity of 304,300 tons of nitrogen, or about three times the nitrogen in our 1939 imports from Chile.



Twenty years ago there were not so many fertilized acres west of the Alleghenies, as this graph shows, and 20 years hence there will be still more west of the Alleghenies and more west of the Mississippi. There is something like an inverse ratio between heavy rain and artificial fertilization, which comes in to replace natural supplies removed by the leaching of heavy rain. Note the small fertilization in the row of states on the agricultural margin, Dakota to Texas. On some of the subhumid wheat lands of this area, water is so distinctly the limiting factor that heavy applications of stimulating chemicals produce no results.

being erected at Belle, W. Va., two years later. By 1935 our output of inorganic nitrogen had increased to 292,000 tons, 60% being derived from the air. Under the stimulus of wartime demand, our total capacity for producing inorganic nitrogen was expanded from 590,000 tons in 1939 to 1,322,000 tons in 1944. Whether this capacity will be used effectively in the postwar era is a moot question. It is certainly true that the most successful farmers in many localities use more fertilizer per acre than their less successful neighbors.

The Fertilizer Industry and Its Location. It is plain why the fertilizer plant, drawing each of its staple raw materials from a different continent, finds the best location upon navigable arms of the sea, so that a shipload of potash from Germany or our Gulf ports, bones from Buenos Aires, or nitrate from Chile, fossil phosphate from Tampa, or sulfur from Galveston, can be unloaded direct from ship to factory. We thus find fertilizer plants established in or near almost every port from Maine to Texas. Nearly half of the nation's fertilizer is manufactured in Georgia, North Carolina, Virginia, Florida, and Maryland, fertilizer plants in this belt of South Atlantic States being well located to serve the cotton, tobacco, and fruit lands of the South and the intensively cultivated truck farms that are scattered along the coast from Florida to Long Island, N. Y. About three-fifths of all fertilizer is consumed in the south-

eastern quarter of this country, a section where the use of chemical fertilizer is imperative, for here excessive leaching has been caused by heavy rainfall that occurs in both winter and summer, by the fact that winters are mild and the earth is almost never frozen solid, by the prevalence of easily leached sandy soils, and by the long-continued practice of one-crop farming in large areas. Coastal plain geology merits mention in the list of poverty makers.

In new countries, especially those with low rainfall, the soils are usually fertile enough to make unprofitable the use of fertilizers, and in the United States their use began in the older east and is now steadily going westward. The manufacture is rapidly on the increase in Ohio, Indiana, and as far west as St. Louis. Upon the more valuable and carefully cultivated lands of western Europe, particularly of England, France, Germany, Holland, and Bel-

Manna. About three-fourths of our atmosphere is composed of nitrogen. It is the chief material for protein—the muscle maker. Fortunately for us, whole tribes of plants become the hosts to colonies of bacteria which form nodules and live upon the roots of the plants, gather nitrogen from the air, feed it to the plants and leave some in the ground for succeeding plants.

Left, life-size nodule of a velvet bean. Bottom right, alfalfa—the milk-producing hay—the valued winter feed of the irrigated meadow in the land of the Great Open Spaces. Top right, three soybeans, the age-old prop of the Orient, the new wonder of the Corn Belt.

gium, the use of chemical fertilizers is very general, and their manufacture is relatively a more important industry than in this country. By the aid of chemical fertilizers lands in Holland, Germany, and our own Atlantic Coast Plain, previously worthless, have been made productive.

The Future of Fertilizer and Fertility. We are agricultural savages just entering the era of artificial fertilization in the United States, because we have an increasing population, soils of decreasing fertility, and the new science of agriculture which is being disseminated with great rapidity. The comfort of our future depends upon commercial fertilizers, almost as much as upon coal or iron. Granted the ability to grow plants abundantly, science can probably adjust and meet man's wants. Man already has learned to restore some fertility to the soil by planting leguminous crops, such as clover and beans, the roots of these plants harboring bacteria that absorb and distribute about 60 pounds of atmospheric nitrogen per acre per year. Without any one of the three constituents, potash, phosphorus, or nitrogen, a field rich in every other requisite of plant growth lies barren. Even the careful Chinese have to abandon otherwise good land where they can get no fertilizer. The world is particularly fortunate in now being able to use the limitless supply of nitrogen in the air. While we probably have enough phosphate rock and potash salts to last for several thousand years, these mineral fertilizer resources are exhaustible, and every ton used today leaves so much less in reserve. In its long-run aspects, no problem is of such transcendent importance as the problem of maintaining soil fertility, for soil is the stuff from which the future must eat!

7. *Soap-making and Its Materials*

Soap is produced by the action of soda or potash upon fats. This chemical reaction causes soap manufacture to be classed among the chemical industries. In the United States the product amounted to $274,000,000 in 1939, or more than 2 dollars per person, and in Europe it is also important. There is a considerable international commerce in soap, but a much greater commerce in its raw materials. Oils and fats used in soap-making, like many other raw materials, seem to be of especial importance in countries of comparatively undeveloped industry. Tallow, olive oil, cottonseed oil, oil of sesame from India, groundnut or peanut oil, and coconut oil are all the basis of large commerce. Many other fatty substances of animal and vegetable origin are also used, even including the grease that is removed from sheep wool in preparing it for the loom.

Tallow, Olive, Cottonseed, and Peanut Oils. Tallow, the standard fat of northern countries, has for a century been the product of the most remote sheep and cattle pasturing districts, and it comes today from the sheep ranches of the Falkland Islands, Argentina, South Africa, Australia, New Zealand, and from central Asia, as well as from slaughterhouses in our big cities. Olive oil is the standard soap fat of Mediterranean countries, and Marseilles is one of the great world centers for the im-

Ceylon, and British Malaya.[35] Although large plantations owned by the Americans in the Philippines and by the British in Ceylon and Malaya are of growing importance, the great bulk of the commercial crop is produced by natives on their little plots of land. Copra is a very durable product when dried, or even when allowed to lie upon the ground, so that it is an admirable commercial product for the easy-going tropic native, who can pick up his crop and dry it ready for the oil press when it suits him. To the South Sea islander copra furnishes the principal cash crop. It supplies directly an amazing variety of wants [36] and also provides the natives with the only means of purchasing the products of the outside world which come to them in small vessels, veritable floating department stores that skirt the populous archipelagoes trading for coconut meats and coconut oils, which finally find their way to the European soap and margarine factories—at Antwerp, Liverpool, Rotterdam, Hamburg, and Marseilles.

Copra is generally exported in full cargo lots in tramp ships, while coconut oil is now shipped in the holds of tankers equipped with steam coils to keep the temperature above 74° F. so that the oil will not solidify. The United States obtains virtually its entire supply from the distant Philippine Islands, which rank second only to the Netherlands East Indies in copra shipments and lead the world in the export of coconut oil. Fresh coconuts for use as food are shipped from nearby Jamaica and Trinidad to ports along our eastern seaboard.

Palm Oil. This oil is another tropic vegetable oil that is of growing importance to soap and margarine manufacturers, especially in Europe. In the rain-forest of the Congo and Niger Basins and along the Gulf of Guinea the breech-clothed African climbs the 30-foot palm tree and cuts off its head of fruit, as big as a basket. The many small fruits are boiled, thrown into a kettle of water, and tramped by bare feet to crush out the oil, which is skimmed from the surface of the water. This is refined by further boiling, and used throughout much of Africa as a choice morsel of food, a substitute for the olive oil of Europe and the butter of America. Almost never will a native chop down a palm tree when he clears a bit of the forest for farming, for the oil of the palm is often his only cash crop. From the seaports of western Africa the oil is usually transported in barrels by tramp ships to markets overseas. On the other hand, palm oil production in the Netherlands East Indies and British Malaya is conducted almost entirely on large plantations, the oil being exported

[35] Among the non-environmental factors that cause commercial production to be concentrated in a few areas are cheap labor, preferential tariffs, and the intangible but effective business and financial ties that exist between a mother country and its colonial possessions. It is not a coincidence that Great Britain imports virtually all of its copra and coconut oil from sources within the British Empire, that the United States imports almost its entire supply from the Philippines, and that producers in the Netherlands East Indies find the mother country to be their major market.—See George F. Deasy, "Location Factors in the Commercial Coconut Industry," *Econ. Geog.*, vol. 17, April, 1941, pp. 130-140.

[36] The leaves of the coconut palm tree serve as thatch for the roof of the native hut, the tree trunk provides building material, the roots yield a dyestuff, coir fiber of the coconut husks is woven into mats and rugs, coconut meat and milk are good food, and the nutshells are shaped into dippers and bowls that may be filled with wine extracted from the flower stems. In brief, it is often said that the coconut tree supplies *all* of the native's wants. That language is slightly figurative, but not very much so.

in tankers. In most years the Netherlands East Indies, Nigeria, the Belgian Congo, and British Malaya produce over 90% of all palm oil that enters the channels of trade.

The kernel of the seed is much like that of a peach seed. It, too, contains oil and is collected and shipped in bags chiefly to the crushing mills of Europe, nearly 90% of the world's palm kernel export coming from Nigeria, the Belgian Congo, French West Africa, Sierra Leone, and the Netherlands East Indies. The Netherlands East Indies palm crop is an introduction, like rubber, cinchona and others.

Here is a suggestive episode. Much of the small export of palm kernels from Liberia is carried for a week or two on the female African head and finally sold to pay for needles and thread and a few other things considered necessary in the native psychology. One year the price of kernels suddenly doubled and the export as suddenly went down 50%. Effective demand for imported goods could be supplied by half as many kernels. Why do more work?

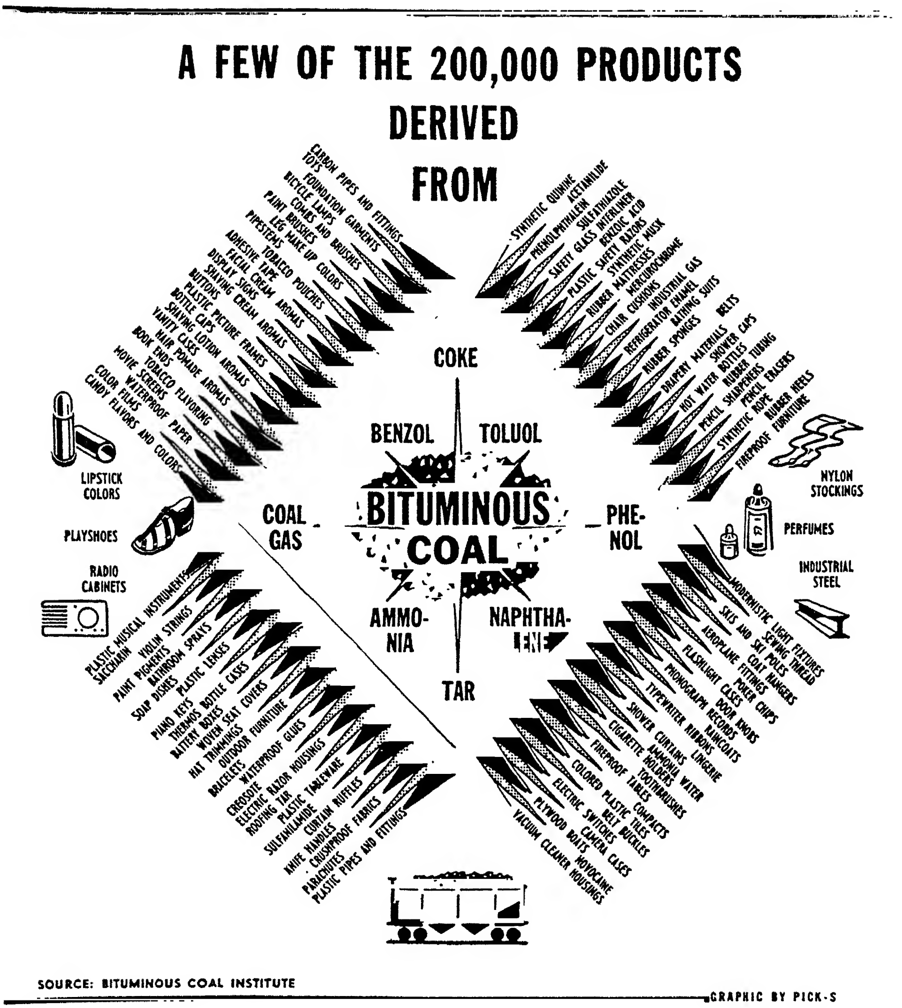
How many of us would work next year if each of us inherited a million dollars tomorrow?

The Soap Industry. The great slaughtering industry of the United States makes its inedible grease into soap materials. Of late the progress in the fuller utilization of by-products has given increasing importance to the manufacture of soap by firms that began as slaughterers of meat animals. The soda ash factories of New York and Michigan produce most of the other raw materials required, and soap factories are quite generally distributed throughout the manufacturing parts of the United States, Philadelphia, Cincinnati, Chicago, and Milwaukee being especially important. Our riches of animal fats combined with our facility in invention, discovery and mass production have given us a large soap industry. Consequently, although we import a few hundred thousand dollars' worth of valuable toilet soaps from Europe, we have come to export thousands of tons of cheaper soap of much greater total value to Europe, and to almost every country in the world.

8. *Coal-tar Dyes*

Natural and Synthetic Dyestuffs. One of the chemical manufactures most typical in its scientific nature, its importance, and its relation to other industries is that of dyestuffs. For thousands of years man dyed his clothing with natural colors made from herbs, barks, and other vegetable and animal products. Their quality has not been excelled. The famous Tyrian purple of the ancient Mediterranean peoples was made from the pulverized shells of certain mollusks. Scarlet was later obtained by the use of cochineal, a dyestuff prepared from the dried bodies of insects native to Mexico and Central America. The rough homespun of the American backwoodsman was dyed a rich brown by the use of butternut hulls.

Artificial dyestuffs derived from that well-nigh infinite chemical mine, coal tar, are of relatively modern discovery. In 1856 W. H. Perkin, an English chemist, while experimenting with aniline, a substance derived from coal tar,



What is in a lump of coal?

produced a purplish or mauve dye. Still other experiments resulted in the chemists' developing a whole range of colors, which became popularly known as aniline dyes. Over 1,600 distinct color dyestuffs have been developed, and the total number of coal-tar dyes recognized by chemists is apparently unlimited. Chemistry has thus turned a former waste product from the by-product coke oven into a source of the rainbow hues used by man in coloring his clothing, and articles of daily use.

The German Dye Industry. While Great Britain led the world in the early manufacture of coal-tar dyes, after 1871 production shifted rapidly to Germany and was dominated by that country until World War I largely because of the outstanding progress achieved by

German universities in chemical education and research.[37] The first aniline colors were so inferior to the natural dyes that people became suspicious of anything named aniline, a prejudice which was hard to overcome. By years of careful laboratory work the German scientists finally produced a range of artificial colors so excellent that they displaced the natural dye products, and so low in price that the rest of the world found it cheaper to buy from Germany than to develop a color industry. Synthetic indigo was so successful that the export of natural indigo from India decreased from 21,000,000 pounds in 1896 to 5,700 pounds in 1938. Only the cheap labor of India makes any export possible. Likewise, competition from synthetic dyestuffs brought about a great decline in the export of dyewoods from the moist eastern lowlands of Central America.

Prior to 1914 Germany controlled the dye industry, with over three-fourths of the world production. In addition she furnished over one-half the primary and intermediate products used by other countries in their limited dye industries. The total export of coal-tar dye products from Germany declined from about $50,000,000 in 1913 to $44,000,000 in 1938.

Rise of the American Dye Industry. Soon after the beginning of World War I, a number of the largest textile manufacturing countries, including Great Britain, the United States, France, and Italy, found themselves cut off from their regular source of dye supply. The development of colors at home became an urgent necessity. The manufacture of coal-tar chemicals had never been seriously attempted in the United States, and the first colors produced by the hastily organized industry were nearly as unsatisfactory as the crude dyes of the early aniline experimenters. However, the manufacturers called in the best chemists, spent money freely on technical research, and finally were able to develop home dyes which compared favorably with the imported ones. Stimulated by the war demand, chemical and dye plants were erected almost overnight and succeeded not only in supplying the home demand, but in capturing a large part of the former German export trade. In 1913 only seven dye plants, including one which was German-owned, were in operation in the United States. No primary dye materials were produced, the plants depending upon imported intermediates. In 1941 there were about 50 dye plants in active operation, manufacturing the

[37] Whereas "academic" and "theoretical" were sarcastic epithets among banking and industrial circles in Great Britain for years prior to 1900, German scientists were encouraged in their research work by both government and industry. After 1870 the superb German chemico-technical schools were almost entirely supported by the state. The successful production of synthetic indigo in 1897 was the culmination of 17 years of patient research and involved an expenditure of $5,000,000. In 1900 about 84% of the technical and sales staffs of all German dye companies possessed formal training in chemistry.—See Theodore J. Kreps, "Modern Dyestuffs," *Encyclopaedia of the Social Sciences,* vol. 5, The Macmillan Co., New York, 1931, p. 302.

For decades science was slighted in the two great (classical) English universities. At the same time, the German universities, until unfortunately prostituted by Hitlerism, were forging ahead in scientific research and training the men who brought smug England to her knees in 1918 and again in 1940.

It is probably true that the professor reached his zenith of public appreciation in Germany in 1890-1914. The nation in which any dominant group can belittle higher education and get away with it is probably doomed to a low position. Woodrow Wilson is said to have defined the practical man as one having a pocketbook and a stomach.

crude as well as the finished colors, and producing 98% of the dyes consumed in this country, whereas in 1914 we imported 90%. The yearly output of the American dye industry is now valued at about $100,000,000, and our dye exports are about five times larger than imports.

This dye story is one of a multitude that might be told to show how unprofitable it has been for Germany to start the two world wars. She began the first in a state of great and growing prosperity. She ended the second in utter collapse.

9. *Plastics*

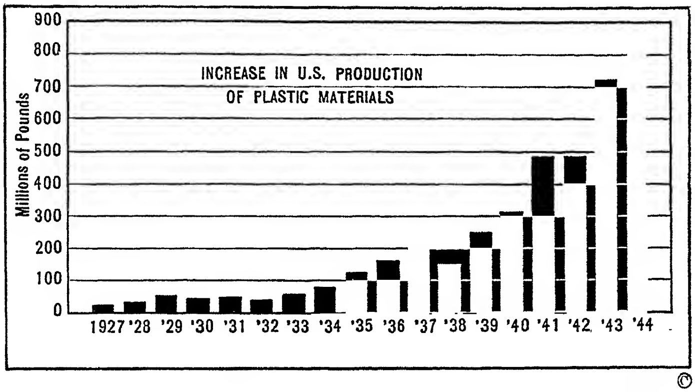
The Nature of Plastics. World War II, with its many substitutions of plentiful materials for those that were scarce, greatly stimulated the manufacture of a group of chemical products known as plastics. These plastic materials consist of a great many compounds devised by the chemist and processed so that they may be formed into innumerable shapes that are durable under a wide variety of conditions.[38] The chemist is a wizard in combining plastic materials to meet almost any specification. Most of these compounds are durable, noncorrosive, light weight, and highly dielectric. Some have a greater tensile strength than steel. Others are lighter than aluminum or magnesium. Some are thin as tissue and can be drawn finer than silk. Some are virtually free from expansion and contraction. Others are fireproof and acidproof. Plastic materials may be transparent, translucent, or opaque, and many of them can be impregnated and therefore permanently colored with any color or hue, a feature that has contributed to the popularity of plastic products with the general public.

Manifold Usefulness of Plastics. With highly diverse and made-to-order qualities, plastics have found a multiplicity of use. Plastics are now employed for structural purposes, competing with metals and wood; they are competitors of adhesives in the manufacture of veneers and laminated wood; they are found as binders in abrasive wheels and as insulating material in electrical equipment; and they afford waterproofing qualities for many fabrics. Plastic materials enter into the manufacture of such diverse products as surgical thread, airplane windshields, ash trays, radio cabinets, varnishes and enamels, buttons, bathroom fixtures, piano keys, false teeth, and automobile steering wheels. Indeed, from compounds made with soybeans, cotton, wood, and other plastic materials were produced more than 100 different parts used in the 1942-model Ford automobile.[39] It is fair to say that plastics are yet in their infancy.

Raw Materials. Among the major plastic materials today is cellulose, the chief ingredient in the fibrous framework of all plants, which is now obtained chiefly from wood and cotton

[38] Some materials, known as thermoplastics, soften when heated sufficiently and solidify upon cooling, while others, known as thermosetting materials, also soften under heat but undergo a distinct chemical change when subjected to additional heat and pressure. For a detailed account of the production and uses of plastics, prepared by the Society of the Plastics Industry, Inc., see "Plastics," *Commodity Yearbook*, Master Edition, Commodity Research Bureau, Inc., New York, 1942, pp. 276-290. Also see Edwin E. Slosson, *op. cit.*, pp. 129-143.

[39] Joseph A. Russell, "Synthetic Products and the Use of Soy Beans," *Econ. Geog.*, vol. 18, January, 1942, p. 35.



Another rocket soars into the industrial sky. Perhaps the most significant thing about this graph, in addition to the tremendous increase in the production of plastics, is the fact that this production had almost no decline in the deep industrial depression of 1932-33.

and which some day may be recovered economically from cornstalks, sugar cane, and other sources. Cellulose is treated with nitric acid to make nitrocellulose, or pyroxylin, the cheapest of all plastic materials, which was used by John Wesley Hyatt in 1869 in the manufacture of celluloid, the pioneer of all plastic products. A recent development in the plastics industry is the use of lignin, the soluble substance that cements the cellulose fibers of wood. Lignin is obtained from wood chips and from the sulfite liquor that formerly was wasted in paper manufacturing, and it is also to be found in corncobs, oat hulls, and sawdust. Another group of plastic materials of growing importance are the protein compounds derived from soybeans, dried blood, milk, and other sources. Probably the most important of all plastic materials at present are the phenol compounds, or synthetic resins made from carbolic acid and formaldehyde, which were first used about 1910 in the manufacture of bakelite. Other competing resins are the vinyls derived from lime and coal and urea formaldehyde obtained from ammonia and carbon dioxide. In making plastic compounds, these basic materials are generally used in conjunction with other ingredients known as plasticizers, including fillers, lubricants, pigments, and dyes.

Methods of Fabrication. Much of the success of the modern plastics industry is undoubtedly due to the great progress achieved in the methods of fabrication, such as the art of molding. To design adequate molds and dies for particular products requires great skill and experience, especially in the production of curved and odd shapes. Indeed, many compounds are known by chemists to have interesting possibilities of use, but they remain of no commercial value because no practical or economical method has been devised to solve the physical and chemical problems of processing and fabrication.

The oldest and most widely used method of shaping plastic compounds is compression molding. In this process pre-formed material is placed in heated steel molds that are closed, heated, and

subjected to pressures of 1,000 to 8,000 pounds per square inch, the material flowing into the mold cavities where it cures in solid and permanent form. If injection molding is employed, the exact amount of plastic material is pre-heated and is forced in viscous form under pressure through a nozzle into a die of one or more cavities, the die being closed under pressure of 10,000 to 30,000 pounds per square inch for a few seconds, after which the finished product is ejected, and the production cycle is repeated. Much of the manual labor formerly used has been displaced by automatic machinery. In contrast with most fabrication of wood and metals, there is very little wastage of raw materials in the molding of finished plastic products.

Some plastic products are fabricated by extrusion, the material in the form of powder, grains, or continuous ribbons being fed into a heated cylinder, whence it is forced by screw or hydraulic pressure through dies that form rods, sheets, tubes, or cross sectional shapes. A relatively new process is lamination, a solution of plastic material being used to saturate layers of fabric, fiber, paper, or wood which are built up in great piles and are converted by heat and pressure into hard and homogeneous sheets, rods, tubes, or other shapes that can be drilled, punched, sawed, or threaded like metal. Thus, the manufacturer, with his cleverly designed molds, dies, and presses, is able to turn out a tremendous variety of plastic products that have come to play an important role in our everyday life. Not least among the contributions of the plastic industry to human welfare is the use of abundant materials, thereby lessening the heavy drain upon our irreplaceable mineral resources. Indeed, the domination of mind over matter, wrought by the chemist, has only begun.

. . . 12

The Forest Industries and Paper

1. The Increasing Usefulness of Wood

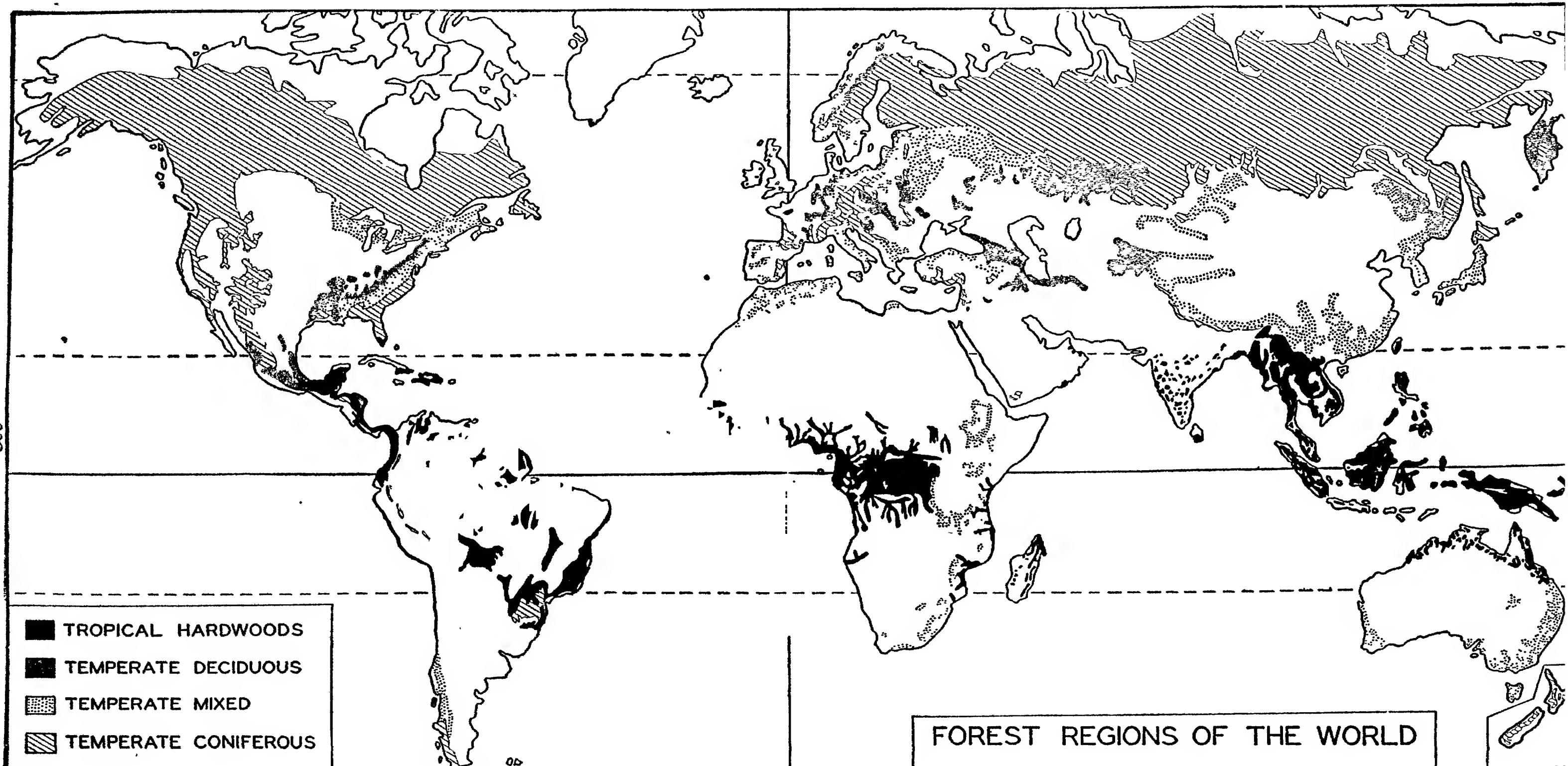
Old and New Uses of Wood. Man cannot get along without wood. It has been useful in all stages of civilization, and the more civilization advances the greater is the service it renders. Man was not much more than an animal until he discovered the use of fire, and from far back in prehistoric time wood has served as fuel. Indeed, in many parts of rural America today firewood is a very common household fuel. Long before the modern era of coal and coke and electricity, charcoal made of wood was the great fuel in iron and steel manufacture, and in primitive lands charcoal is still used in metalworking. As late as 1935 firewood supplied more of the world's inanimate energy than water power and natural gas combined (see Table 4).

When man settled down to agriculture, he used wood for his plow, for his house, for the barns for his cattle, and for the fences that limit his land and keep his animals from wandering away. Down through the ages countless objects have been made of wood, which continues to serve as one of the world's prime building materials particularly where it is plentiful. Furthermore, the movement of men and goods has long been facilitated by the use of wood in vehicles of transport, as in the sled, two-wheeled cart, wagon, ship, railway car, automobile, and airplane. For centuries prior to the modern era of cheap iron and steel, the hull and ribs of the world's ships were made of sturdy oak, the masts and spars being shaped from the lordly pine. In our new era of air transportation, the cargo plane that spans the world's continents and oceans tomorrow may well be made of plastic and wood with the strength of steel and half the weight of aluminum. To carry the world's goods hither and yon, surprising quantities of wood are needed for barrels, boxes, crates, and other containers, nearly half of the entire American output of lumber during the war year of 1943 being used to hold military supplies.

In the diffusion of human knowledge and ideas, wood is indispensable, for the printed page of every book, magazine, and newspaper is paper now made chiefly of pulp derived from cellulose, the hairlike fibers that comprise 65% to 80% of all wood. Cellulose is also a basic material in the manufacture of rayon, cellophane, alcohol, and many chemicals and plastics, while the soluble lignin of wood is used as a binder for plastics and has many chemical possibilities.[1]

Each day some inventor finds a substitute for wood in one of its uses, but other inventors find corresponding new

[1] See "The New Age of Wood," *Fortune*, vol. 21, October, 1942, pp. 117-121 ff.



Anyone looking at this map should remember that it is on the Mercator projection with its gross exaggeration of areas in high latitudes. He should look at once at a homolosine such as the world climate regions to correct this erroneous impression.

Perhaps Africa contains the greatest surprise. A good many people think it is mostly either jungle or Sahara. Of the two it is more Sahara than jungle.

uses for it, so that our dependence upon it is increasing day by day.

2. *Forest Depletion and the Migration of Lumbering in the United States*

The Destruction of American Forests. On every continent at one time or another, great tracts of primeval forest have stood as an impediment to the movement of man and the spread of agriculture. To the early settler in eastern America the dense forest was an enemy as well as a friend, an obstacle as well as a resource, and his first effort was directed against the forest, which he worked laboriously to clear away before he could plant a crop. He then had to struggle for years with the stumps before he could have a smooth field to grow his food. Decade after decade, through the seventeenth, eighteenth, and first half of the nineteenth centuries, the occupation of the country east of the Mississippi went steadily forward, accompanied by the destruction of the forest to make room for the plow. In this process millions of fine trees were rolled into piles and burned to get rid of them, because at the time there was no accessible market where they could be sold. In the early years of forest clearance the necessary lumber for local use was cut in a little sawmill adjacent to a waterfall, the water wheel driving a big upright saw up and down and ripping off the boards one at a time for the man who brought his logs to the mill. In more recent times the circular saw has replaced the upright saw and has greatly accelerated the manufacture of useful lumber from logs, and in many cases the rapid double-cutting band saw has replaced the circular saw, especially for the large logs in the western mills.

Regional Shifts in Lumber Production. As the nation's population continued to grow, as the demand for lumber increased, and as transportation facilities improved, one tract of virgin forest after another yielded to the ax and the saw. The denudation of forests

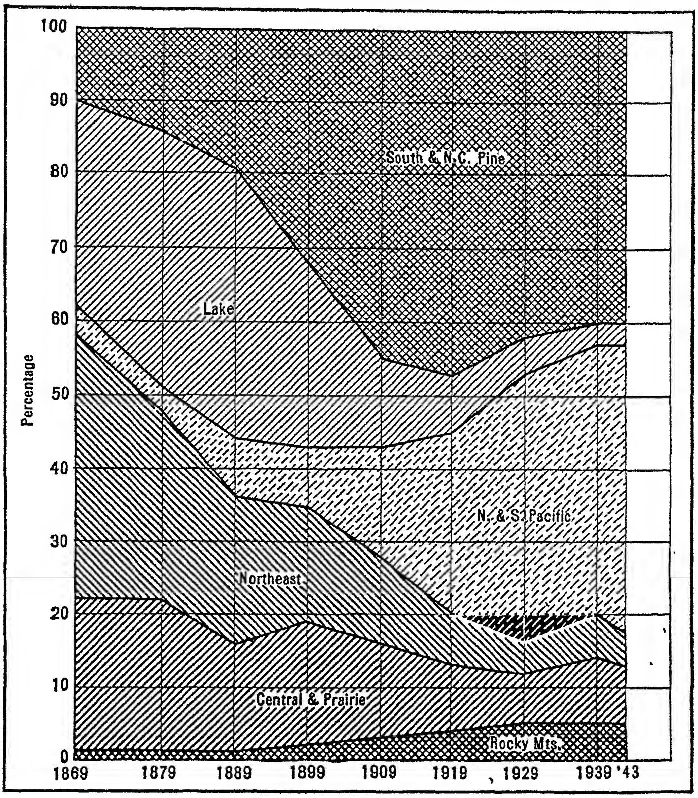
Note that these trees have been deadened by girdling to make pasture land and stand to rot their time out. Photographed, 1939, in the Mark Twain National Forest, Missouri.

Roaring Lion Canyon, Bitterroot National Forest, Montana. Every tree is killed. See how little trees in the foreground have been burned off completely and all the porous leafy soil eaten out from between the rocks. This is one of the first stages in the all too true saying, "After man, the desert."

naturally began in New England, New York, Pennsylvania, and other eastern states, where the lumber industry was oldest and where the needs of dense populations were great. In the early eighteen-fifties Chicago became the largest lumber market in the world, shipping vast quantities of Michigan and Wisconsin lumber through the Illinois and Michigan Canal [2] and later by rail to thousands of growing towns and cities and hundreds of thousands of farms on the treeless prairies of the upper Mississippi Valley. The first great shift in the center of lumber production occurred in the eighteen-seventies, when the output of Michigan, Wisconsin, and Minnesota surpassed that of the northeastern states. In the closing years of the century leadership in lumber production passed from the three Lake states to the South, and again in 1927 it shifted to the Pacific Coast (see Fig. 335).

For years the northeastern and Great Lakes states have been obliged to import lumber from other sections of the country (see Fig. 336), and in 1941 their combined production was less than 7% of the nation's output. In the warm South, where trees grow most rapidly, the lumber industry is now almost entirely dependent upon second-growth timber. Only in the Far West do important and readily accessible stands of virgin timber remain. Of the nation's total production of 28.9 billion board

[2] This canal, opened in 1848, connected Chicago with La Salle at the head of navigation on the Illinois River. Lumber from Chicago was carried by boats traversing the inland waterways as far west as Lexington, Mo., and Fort Leavenworth, Kans.

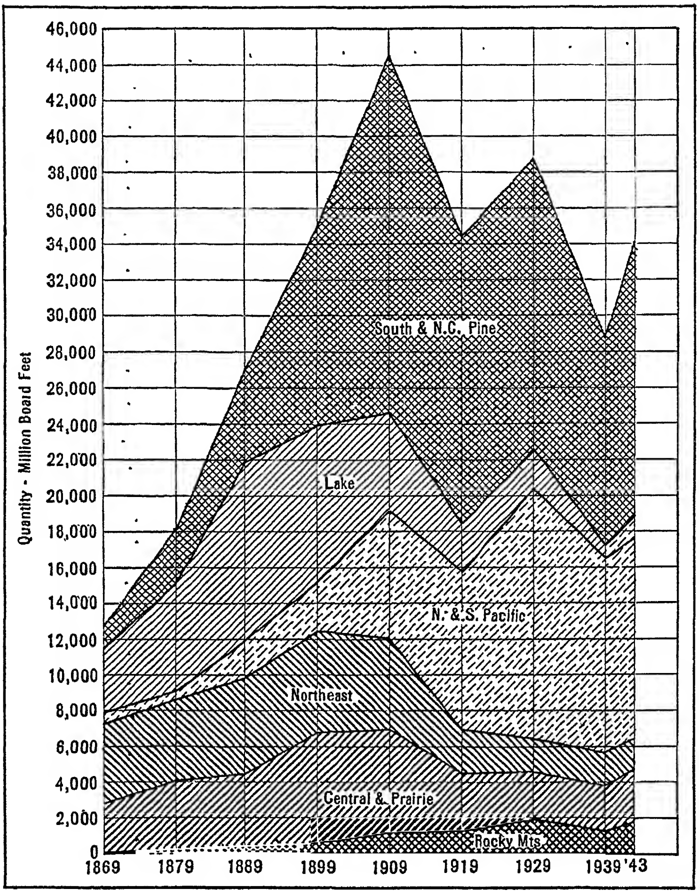


The estimates of *percentages* of lumber production by regions, 1869-1943, show remarkable shifts. The mighty are fallen and the small have been raised up, but can they stay up?

feet of lumber in 1941, about 41% was cut in Oregon, Washington, and California, or slightly more than the entire lumber output of a dozen southern states. The migration of lumbering into the South and Far West greatly lengthened the haul and increased the cost of transporting lumber to the great market east of the Mississippi and north of the Ohio and Potomac Rivers which normally consumes more than one-half of all lumber used in the United States. For more than 50 years we have been confronted with rising lumber prices, which have more than doubled since 1900,[3] the inevitable result of an unabating demand, dwindling supplies, longer hauls, and prodigious waste.

The Transportation Factor. Lumbering is an industry that is vitally dependent upon favorable conditions of transportation to mill area and to mar-

[3] Between 1899 and 1940 the average mill value of all kinds of lumber in the United States—excluding transportation and other marketing costs—increased from $11.13 to $23.32 per thousand board feet. During this period white pine increased from $12.69 to $27.87, spruce from $11.27 to $26.84, yellow pine from $8.46 to $21.35, ponderosa pine from $9.70 to $24.29, and Douglas fir from $8.67 to $19.49. And mills have increased in efficiency the while.—U. S. Dept. of Commerce, *Statistical Abstract of the United States, 1942,* Washington, 1943, p. 825.



Like Figure 335, this is estimated production of lumber by regions, but shown here in *quantity,* not percentages. It is suggestive to note that we reached our peak in 1909. The rising price of lumber is pinching off consumption.

ket. Sometimes a log must be carried for miles from the stump upon which it grew to the sawmill where it becomes lumber. Since the big log is more difficult to transport than the smaller boards, the sawmills are situated as near as possible to the place where the trees grow. The mill is often portable, moving about the woods sawing the logs of a few acres in each place, thus minimizing the log hauling. A large sawmill is usually found only where the logs can be floated down a river or brought in by rail or truck, so that it can draw its supply for many years from a large territory. While logs are shipped comparatively short distances, lumber is often carried hundreds or even thousands of miles to market. This heavy, bulky, low-valued commodity, which in the past has sold for less than a cent a pound, must be transported at low rates if it is to be moved very far and still yield a profit. Thus, large quantities of lumber are shipped cheaply from the Pacific Coast by ocean vessels via the Panama

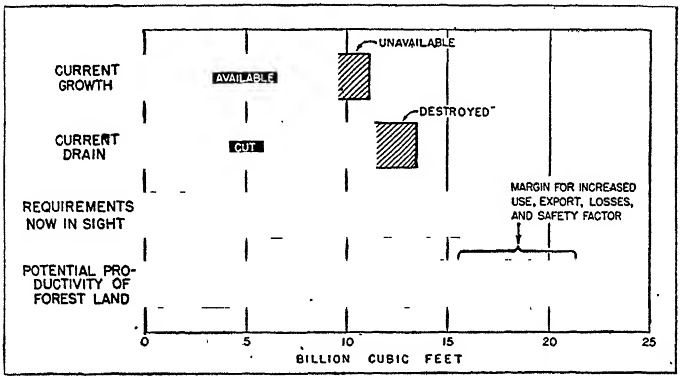
Some of this temporary desert is national forest. Some is privately owned land. The kill is complete, no seed trees left. It will have to be planted, a laborious process with a long wait, much longer than if big trees had been lumbered and small trees and little trees left and fire kept out.

Canal to our eastern seaboard, and considerable quantities of southern lumber move by barge on the Mississippi River system. Our railroads, however, have long quoted sufficiently low rates to obtain most of the lumber traffic, which in some years requires the use of approximately 3,000,000 freight cars.

Adaptation of Species to Use. The changes in price, the exhaustion of local supplies and the competition of the different lumber fields give a great variety of lumber to the eastern United States. The joists (floor supports), which used to be of hemlock, are now partly supplied by old field pine grown on abandoned corn and tobacco fields in eastern Virginia and the Cotton Belt. If the outside of a building is of wood it may be made of fir from the Pacific Coast in place of white pine from northern forests. For interior finishing, cypress and Georgia pine have replaced Maine pine. The flooring is the hard pine of the South, the shingles are usually cedar of the state of Washington, which has replaced the almost extinct cedar from the swamps of New Jersey, or cypress from the Dismal Swamp of Virginia. Nearly all American cities have an equally wide supply and have had equal shifts in its source.

As a result of more than three centuries of tree slaughter, our heritage of forest land has been greatly reduced. It is estimated that the original forests of the United States covered 822,000,000 acres and contained 5,200 billion board feet of lumber.[4] In 1938 our commercial forests occupied about 462,000,000 acres,

[4] Raphael Zon, "Forests," *Encyclopaedia of the Social Sciences*, vol. 6, The Macmillan Co., New York, 1931, p. 383.



United States forest growth, drain and requirements, and potential productivity of forest land. We should say, if, if, if—it is permitted to produce. Tens of millions of acres are not permitted now to produce because of fires and pasturing, often deliberate fires to encourage pasturing or huckleberries.

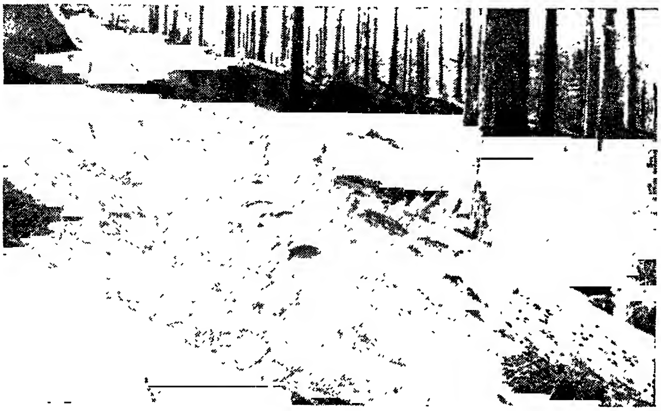
but only 213,000,000 acres were covered with timber of saw-log size of which less than half was virgin growth.[5] Our total stand of saw timber amounted to 1,764 billion board feet, more than three-fifths of this stand being located in the Pacific Coast states. For some years we have been using timber at least twice as fast as it grows.[6] No people past or present have used and abused their forest resources as have the people of the United States, and the real rub will come when the Pacific Coast supply is gone. The natural forest area of the United States comprises almost all the country between the Atlantic Coast and an irregular line extending from the mouth of the Rio Grande, to the Canadian border near the western boundary of Minnesota; a large area in the higher regions of the Rocky Mountains; and the Pacific forests on the Sierra Nevada and Coast ranges. It is too dry for tree growth on the lower lands of California, of the Rocky Mountain region, the Great Basin, and also on the Great Plains. The prairie fires set by Indians to remove old grass from the pastures are supposed to have kept down the forest in large areas of the Mississippi Valley where trees now thrive, when man gives them a chance. Parts of the Shenandoah Valley of Virginia and West Virginia are for the same reason said to have been devoid of forest at the time of settlement.

3. *The Lumber Districts of the United States*

Northeastern District. The first of seven major lumber districts is the northeastern, comprising the upper New England and Adirondack forests, occupying a highland with a climate rather too cold for satisfactory agriculture. Much of this cold country is impossible of tillage because of its steep and rocky surface. It was made rocky and also swampy and sandy by the

[5] U. S. Dept. of Commerce, *op. cit.*, p. 818.

[6] See U. S. Forest Service, *A National Plan for American Forestry*, vol. 1 (Senate Doc. 12, 73d Cong., 1st Sess.), Washington, 1933, pp. 208, 221.



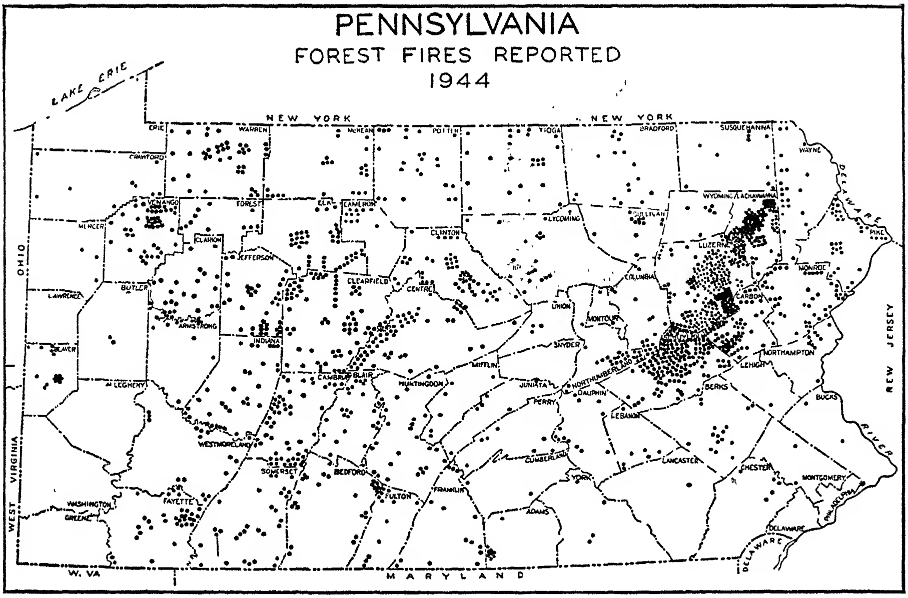
Note the men in the center foreground and in the distance, trees—three or four, or perhaps five feet in diameter, still standing, but so dead there are no seed to reproduce the murdered forest, hence the gang of planters.

work of the overriding ice in the glacial epoch. But its rocky, swampy, and sandy soils can, if properly cared for, give us crops of wood indefinitely. This lumber district, being easy of logging and near to cities, was the first in the United States to be exploited on a large scale. The cold winter and heavy snow of this northeastern highland have long been essential factors in the lumber industry, because in winter the earth is frozen hard and covered with ice and snow, enabling teams and tractors to haul logs on sleds to stream-side, where the melting of the snow in spring furnishes the freshets which carry the logs downward to the mills. Thus Bangor, Maine, on the Penobscot, became a sawmill center. With the building of more and better highways and secondary roads and with the increased use of tractors and motor trucks, the picturesque and dangerous log drives have almost become a thing of the past.

The most important timber tree of this forest region was originally the white pine, which yields one of the very best of woods. It is prized for its lightness, strength, durability, freedom from warping, cracking, shrinking or splintering, and the ease with which it can be worked.[7] First the lumbermen took the virgin pine; then, spruce, hemlock, fir, and second-growth pine; while now they cut chiefly short stuff for the pulp and paper mill. In addition to these easily worked and salable softwoods are the broad-leafed trees, including the maples, beeches, birches, and oak, which are often scattered through these forests, forming a rather large part of the forest growth in this and the next lumber district.

The Great Lakes District. The second lumber district is that around the upper Great Lakes, which is climatically and industrially a sort of separated western half of the New York and New England field. Similar glaciers overrode the states of Michigan, Wisconsin, and Min-

[7] "God made pine," says the carpenter, and, as he pulls a splinter from his thumb, "the Devil made hemlock."



The location of forest fires reported in one state for one season. The anthracite coal field is most clearly and tragically marked out. The man who invented matches was certainly one of the enemies of the future timber supply.

nesota, leaving in their northern parts similar sandy, rocky, and swampy areas. The likeness to the Northeast is completed by the predominance of the white pine, the spruce and the hemlock, while the lumbering operations are carried on with the assistance of snow and ice in winter. Lumbering in this district began in the lower peninsula of Michigan, then went to the upper peninsula. Then Wisconsin succeeded Michigan as the leading state, but as her forests diminished she was in turn succeeded by Minnesota. With the exhaustion of the white pine, many lumber companies migrated to the South. So thorough was the destruction of the forests that all the Lake states had become lumber importers by 1920.

Appalachian Forests. The third lumber district is that of the Appalachian Highlands, reaching from southern New York to the northern parts of Georgia and Alabama. This plateau, becoming higher as it goes south and reaching its maximum elevation in North Carolina, extends the temperature of New England far into the south and with it the trees of New England. Some hemlock is found in western Carolina, West Virginia has much hemlock and spruce, with some yellow pine and some white pine, while hemlock (the state tree) has long been a standard timber from the Pennsylvania mountains. In this Appalachian district the steepness of the mountains and the small amount of snow make impossible the extended use of sleds as in the New England, Adirondack and Great Lake forests, and the logs are moved to the mills on wagons or, in some cases, on chutes of logs or steel down which the logs slide from precipitous hills to a

temporary railway in the valley below. The virgin timber has been virtually exhausted, and second-growth trees are now being cut in most of this region. By 1910 carloads of lumber were regularly shipped into Pennsylvania districts from which twenty-five years previously it was sent out by the trainload.

Central Hardwood Forests. The fourth lumber district is the middle region of hardwoods extending from New York to Alabama, from Louisiana to the lower Great Lakes, and westward to the western edge of the Ozarks near the boundary of Kansas. The evergreens, spruce, pines, and hemlocks hold the top of the Appalachians, and pine trees grow naturally upon the sandy Atlantic plain, but between these two on the lower slopes of the Appalachians and the hilly country leading up to them on both the eastern and western slopes is a large area where the forest is made up of the broad-leafed trees, oak, hickory, tulip, black walnut, and to a lesser degree ash and basswood, classed as hardwoods by the Forest Service.[8] This is the region from which the American supply of these hardwood timbers has chiefly come, although they are produced to a lesser extent in both northern and southern forests. Lumbering on a large scale was done earlier in the eastern part of this hardwood district than in the western; at the present time Louisiana, Mississippi, Arkansas, Tennessee, Michigan, West Virginia, and Wisconsin are the states of greatest production. Chattanooga and Evansville, Ind., are important markets, and Memphis is the greatest hardwood market in the world. Oak, red gum, maple, and yellow poplar are now the leading hardwoods.

Southern Pine Forests. The fifth lumber district is that of the southern pines, extending in an almost continuous forest along the Atlantic coast plain from Long Branch, N. J., to Austin, Tex. The most important trees of this district are the longleaf, shortleaf, slash, and loblolly pines. The strength and hardness of longleaf pine makes it prized for flooring, interior woodwork, and many other uses. In 1940, southern pine furnished about 40% of all the lumber cut in the United States. Lumbering is much easier than in New England or the Appalachian district, for much of this southern country is sandy and level, some of it gently rolling, but none of it is rugged. Furthermore, the warm climate makes lumbering a year-round activity. For many years the logs have been carried to the nearest sawmill on temporary railroads, which are put through the woods about 2,000 feet apart so that a donkey engine winding a cable 1,000 feet long can draw logs from any part of the woods to the side of the railroad track, but in recent years tractors and trucks have come into increasing use.

The ease of lumbering has made for reckless cutting, and today three-fourths of the remaining stand of saw timber in the South is second growth. Virtually all of the virgin pine is now gone, and

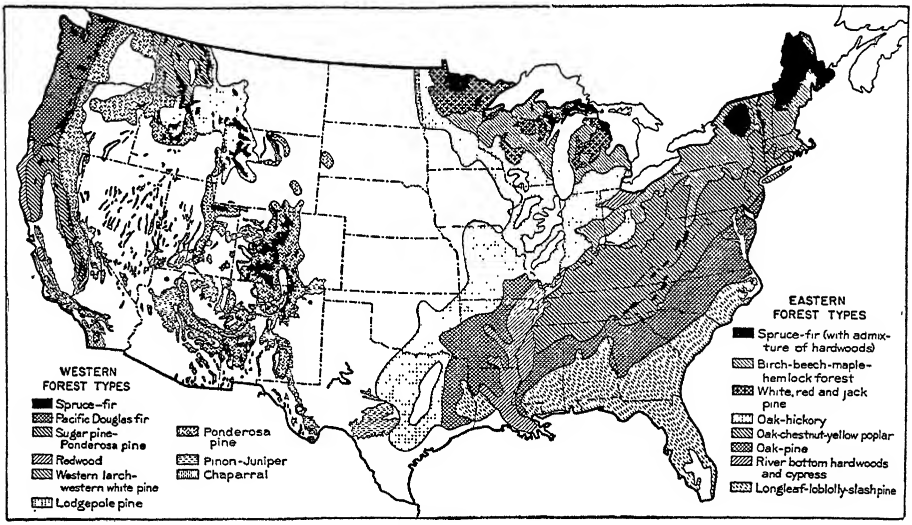
[8] Principal Commercial Woods as Classified by the U. S. Forest Service:

Softwoods

Pines	Spruce	Cedar
Firs	Cypress	Larch
Hemlock	Redwood	Tamarack

Hardwoods

Oak	Beech	Ash
Maple	Birch	Hickory
Poplar	Basswood	Walnut
Gum	Elm	Sycamore
Chestnut	Cottonwood	Cherry



This map of the United States should be taken as one showing land where certain kinds of timber will grow rather than a map of forests. Some of the areas, especially the mountain areas are, of course, forests, of a kind.

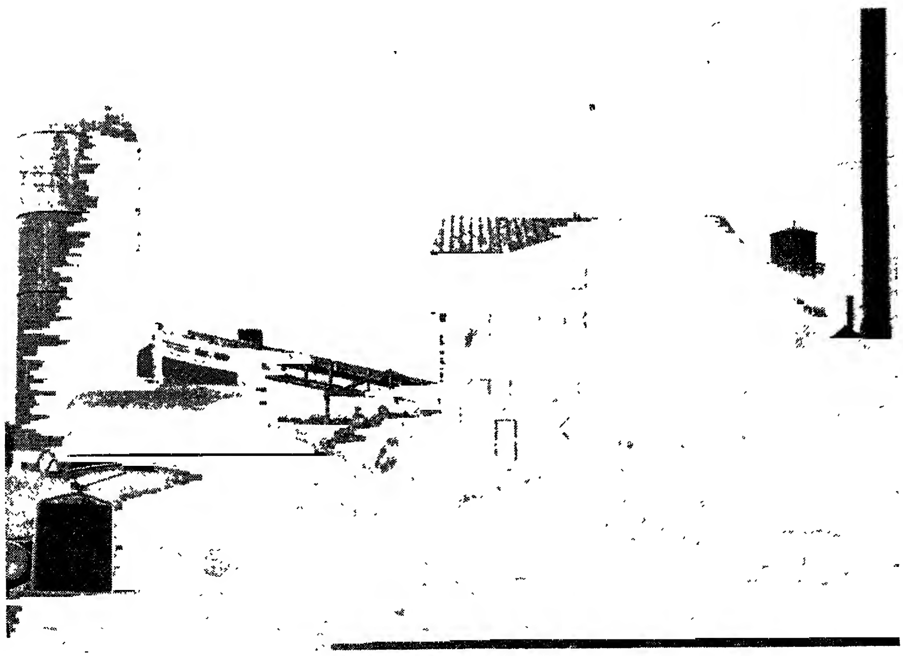
the South has become dependent upon second-growth timber for most of its lumber. No section of the country can equal the warm and rainy South, particularly the Gulf states, in rapidity of tree growth. In southeastern Texas a lumber company finds that it can cut timber on a large tract of land every five years, if it takes no trees smaller than 15 inches in diameter; the removal of larger trees leaves more light and fertility for the smaller trees, which add a ½-inch ring (an increase of 1 inch in diameter) each year; so in five years 15-inch trees become 20-inch trees and good saw logs as the result of selective cutting. In contrast with red spruce trees in Maine that average only 1.8 inches in diameter when they are seventy years old, loblolly pines of the same age average 24 inches in diameter. Since the South has a climatic advantage in tree growth and is also located much nearer to the major lumber markets than the Pacific Coast states, it is quite likely to be the nation's chief source of timber in the future. And, furthermore, since the Herty process in 1933 made it possible to manufacture newsprint out of pulp made from loblolly and slash pine only seven to nine years old, the South may emerge as the nation's leading producer of newsprint paper.

The combined coastwise and export trade in this southern lumber region still involves large shipments from the ports of New Orleans, La.; Mobile, Ala.; Pensacola, Fla.; Brunswick and Savannah, Ga.; Charleston, S. C.; New Berne, N. C.; and Norfolk, Va.; while at one time the small town of Gulfport, Miss., was one of the greatest lumber-shipping points in the world. Vast quantities of southern pine are also sent by rail into the Ohio and Mississippi Valleys.

Another important timber tree in the southern field is the cypress, used for

interior finishing and especially for shingles and exterior work where a decay and weather resistant wood is needed. It is one of the few trees that will grow in a swamp, where its roots must be under water. The shifting source of cypress well illustrates the growing shortage of lumber, and the reasons for its rise in price. Norfolk used to be the great cypress market, but the comparative exhaustion of the Dismal Swamp supply caused Florida to succeed Norfolk, whereas scarcity in Florida was followed by the rise of New Orleans as the chief market for the product of this swamp forest tree from the swamps of the Mississippi bottoms. Of increasing importance, too, are the gumtrees and a few other varieties formerly considered worthless for lumber and left standing while cypress was being taken out.

Forests of the Western Mississippi Valley. The central part of the Mississippi Valley north of the Ozark Mountains, is our sixth lumber district. It was partly covered with mixed hardwoods when occupied by the homesteaders in the second and third quarters of the nineteenth century. Ohio and Indiana had magnificent forests of oak, hickory, maple, ash and elm. Illinois was transition ground where fine hardwood timber alternated with large patches of open prairie. Only along the streams of Iowa, Kansas and Nebraska was there forest. The scattered growth of broadleafed trees was of great value to the early settlers, furnishing them with wood for buildings and fuel. Most of



Sawmill at Flagstaff, in the Arizona highlands. Logs rolling from a truck into the pond whence they float to the chute, where one can be seen going up into the mill by belt conveyor. At the left, the cylindrical building is the burner for refuse which at this time and place and price cannot be used.

this timber has been gone for many years.

At the North the humidity in the glacial swamps and the lakes had preserved forests west of the source of the Mississippi (see Great Lakes district above) and at the south, the Gulf rains had extended the southern forests over east Texas and the hardwood forests over the Ozarks. From the Missouri River to the Rocky Mountains, from Canada to the Rio Grande was a timberless area with one oasis of forest on the small highland, where the Black Hills of South Dakota and Wyoming, with a greater rainfall, still supports a rather inferior tree growth.

The timber mine. For some centuries nature has been adding an annual ring of wood to this Washington State (western part) giant, typical of the finest, richest timberland in the world, now rapidly being slaughtered and often being burned immediately thereafter.

Rocky Mountain Forests. Owing to the slight rainfall at low elevations, the Rocky Mountain forests grow only in high elevations, particularly in the South, but the lessened heat and evaporation make the area of the forest increase in Idaho and Montana. The cool north sloping valley side often has trees while the south slope is bare. These Rocky Mountain forests, because of their dependence upon elevation, occur in scattered patches which increase in and toward the North. The percentage of forest area is comparatively small in New Mexico, but it has many more square miles of forest than has New Hampshire. There are even several thousand square miles of fine open forest upon the plateaus of northeastern and central Arizona, and there are large extensions of this same plateau forest in the mountains of northern Mexico to which no railroads have yet been built.

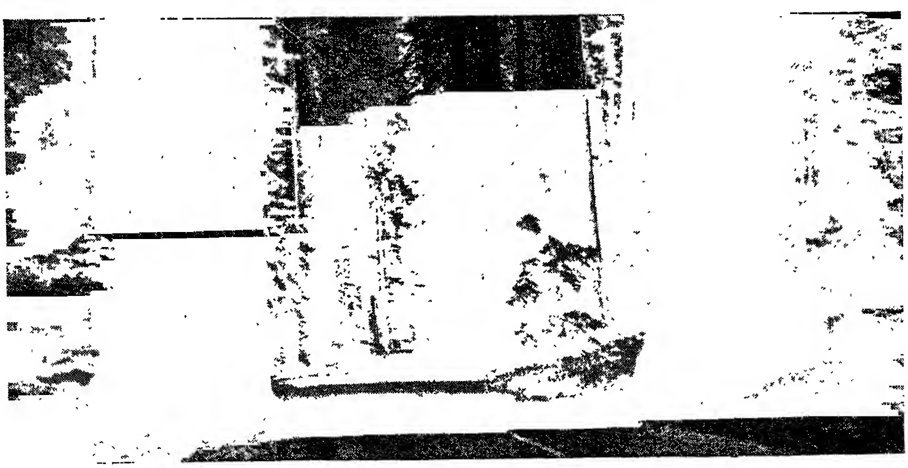
Owing to the prevailing coolness resulting from elevation, the Rocky Mountain forests are mainly coniferous; they include chiefly the western yellow, ponderosa, and lodge-pole pine, Engelmann spruce, Douglas fir, and western red cedar. Vast tracts of timber land have been sadly injured or completely desolated by fire, and many areas are so rugged and inaccessible that they may never be cut. In recent years more than three-fourths of Rocky Mountain timber production has occurred in Idaho and western Montana, where the largest and best stands of saw timber are found.

To get logs down precipitous slopes, around mountain spurs, and out of deep ravines, Rocky Mountain lumbermen have had to perform many an engineering miracle. As a general rule, logs are floated out in water-filled flumes or

board troughs that may extend for miles from the logging scene to the nearest narrow-gauge railroad or sawmill. Many a flume emerges from a deep and crooked gorge that not even a donkey could enter. As a result of local inaccessibility, remoteness from market, and the prevalence of inferior growth particularly in the southern part of this district, the Rocky Mountain states contribute only about 5% of the nation's annual timber supply.

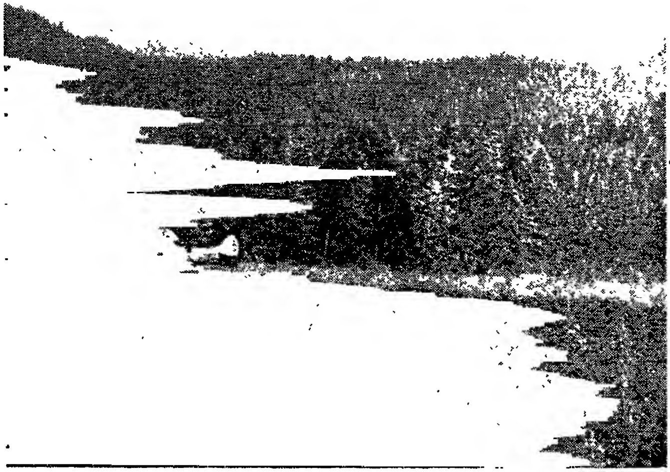
Forests of the Pacific Slope. The seventh forest district of the United States and the finest in the world is that near the Pacific coast. This forest belt begins about latitude 35° in California, where it occupies the Sierra Nevada and Coast ranges, but low rainfall causes the great valley of that state lying between these mountains to be treeless, save along streams, as are the lowlands farther south and east. In northern California the forest covers the Coast Range, Klamath Mountains, and the Sierra Nevada; and in Oregon and Washington it covers the Coast Range and Cascades and much of the intervening valley land. The second system of mountains, as we go inland (Sierras and Cascades), sharply limits the rainfall so that, except upon the higher ranges, there is no forest in the Great Basin between the east front of the Sierras and the Wasatch Mountains of Utah, nor between the Cascade Mountains of west central Washington and Oregon and the mountains of Idaho, except where the Blue Mountains of northeastern Oregon lift their lands up into the altitudes of coolness and moisture and hence of trees.

The even climate, a good rainfall, freedom from windstorms, and a dry summer, checking fungous action, permit the trees of the Pacific forests to grow for ages and attain great size, as is shown by the well-known tree, the "big tree," of California, which towers for 200 to 300 feet above the earth and at-



A glorious legacy of the past. The giants along the Redwood Highway, Humboldt County, California. Note the automobile in the distance.

There are communities in the Northwest that once had trees like these and where now the local inhabitants do not even know what such a tree looks like, hence the effort to save a few precious remnants for spiritual and intellectual appreciation.



The airplane is now an effective part of the fire patrol, even in fire fighting, in many forests. Also by spreading dust, as here shown, it may become effective in combating forest insects, of which some, such as the bud moths, are amazingly destructive.

tains an immense girth.[9] The redwood is one of the sequoias, and all are classed as pines. The thick stands of California redwood, and the Douglas fir, western larch, and white and ponderosa pine in all three Pacific states are more important than the famous giant sequoias. Many of these trees grow from 4 to 8 or even 10 feet in diameter with straight trunks 100 feet and even more in length. It is difficult work to get these huge logs to the sawmill. Because of this difficulty much fine timber is wasted.[10] As it is utterly impossible to haul them on on an ordinary wagon, they are sometimes dragged by donkey engines or tractors over a roadbed paved with small logs. Oftener they are taken on temporary railways, and sometimes they are allowed to slide by gravity down log chutes. The largest must often be split by blasting before they can be moved at all. The lumber is manufactured in the largest and most perfect lumber mills in the United States, some of them using every particle of the log that is brought to their wonderful machinery. A typical mill may produce shingles, lumber, and match-sticks from the finest portions of the logs, while the sawdust and bark feed the engine fires.

Often, however, there is an extra fire burning unused waste. Tramp ships have for years loaded at Seattle, Tacoma, and Grays Harbor, Wash.; Vancouver, B. C.; Portland, Ore.; Eureka and Humboldt, Cal., to carry the excellent timber to markets of South America, Australia, Japan, South Africa, and even to England, France, and Germany, a voyage equal to almost half the distance around the world. Low railway

[9] The wood of the big trees is almost unburnable and the thick bark holds water in a most unusual way—a great pair of fire-protective qualities.

[10] Lumber was wasted on the Pacific coast more than in the East and South, because the haul to eastern markets was too long to pay for making up cheaper stuff—boxing, crates, etc. Only the best of the lumber could be profitably worked up and shipped.

rates and the increased price of lumber in the United States permit the Pacific Coast lumber to be carried across the continent to Chicago and even to New York. For years lumber has been a major article of freight eastward upon the transcontinental railways.[11] The three Pacific Coast states now contain approximately two-thirds of our remaining saw timber.

4. Canadian and Alaskan Forests

The Forests of Canada. Four of the forest belts of the United States touch and extend across the Canadian boundary. The Pacific and Rocky Mountain forests combine in Canada, extend northward through British Columbia and on to the Yukon, a vast region crossed as yet by but two railroads, the Canadian Pacific near the United States boundary and the Canadian National farther north, so that most of it is unsettled and little known except to the trapper and prospector. It contains, along with a little land good for agriculture, many forests that have excellent prospect of being burned before we can get their product upon the world's market. The treeless belt of the Mississippi Valley goes northward through Canada until between latitude 50° and 53° the moisture conditions for forest growth are again found and there is a connection between the Rocky Mountain forests and the forest region north of the Great Lakes in a subarctic forest belt 400 to 500 miles in width from north to south.

The whole of the country from near Winnipeg to the Atlantic was originally a forest of which but a fraction has been cleared for settlement in the region between Lakes Erie, Ontario, and Lower Huron, and in the St. Lawrence Valley. North of this small inhabited belt is one of the great forest reserves of the future reaching from near Lake Winnipeg to the mouth of the St. Lawrence and from Hudson Bay to Georgian Bay, the Ottawa River and in places to the banks of the St. Lawrence itself. Much of it is upland, it is well sprinkled with lakes and marshes, and is practically unsettled, except by a few Indians, fur trappers, miners and summer fishermen.

One railroad extends northward across this primeval forest, a government-built line that connects the Canadian National Railroad system in eastern Saskatchewan with the port of Churchill on Hudson Bay.[12] A second line extends northward from Cochrane, Ontario, to Moosonee on James Bay. Another railroad traverses the forest from the south end of Lake Winnipeg to Quebec, while a few branch lines extend northward to a few scattered mining communities. Thus far, lumbering has been confined to the accessible southern edge of this great forest region. The Ottawa River has long been a good outlet, and the city of Ottawa is an important lumber market.

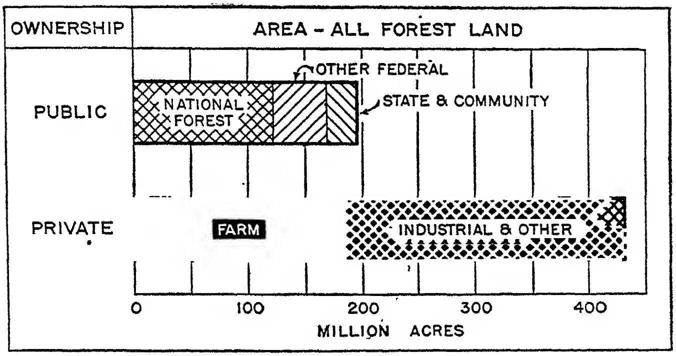
In its northern part this forest thins out through a wide area of scrubby

[11] Of the total railway freight originating in the Pacific Northwest (Washington, Oregon, Idaho, and Montana), forest products account for more than 60% of the tonnage and yield more than 40% of the revenue.—National Resources Committee, *Forest Resources of the Pacific Northwest,* Washington, March, 1938, p. 68.

[12] This 510-mile long railroad was sponsored by politicians to "help" the spring wheat farmers on the prairies of Manitoba, Saskatchewan, and Alberta south of the forest by providing a shorter route to Europe via Hudson Bay, but, since the great bay is closed by ice for all but six or eight weeks of each year, the railroad has little traffic.

This splendid map of natural forest lands should be compared with the Mercator map earlier in this chapter. In considering the vast area of Canadian forests, it should be noted that the Northern limits do not merit the name forest if saw timber is a part of the concept—there is tree growth—some tree growth—yes, but sawlogs? or commercial access? (Baum's *Atlas of U. S. A. Electric Power Industry.*)

forest and bush to the Arctic, home of the caribou and reindeer. Unfortunately these forests have suffered terribly from fire, and the rate of growth of the trees is very slow. As acquaintance with Canadian forests advances estimates of their resources dwindle. Explorers traveling by canoe, the only way to travel through this country, have seen stream bank forests which they could with difficulty penetrate because of the thick undergrowth of juniper and other scrub



This graph of ownership of American forests is one in which there is steady gain in public ownership, but usually not until the forest has been first destroyed. Do not forget the distinction between forest land and forest. Much land in "National Forests" has no forest.

stuff. Aerial photographic surveys show that they made the mistake of inferring that the inter-stream spaces were equally good, whereas many of them are without timber.

A continuation of the New England forests occupies most of the Canadian territory between the St. Lawrence and the Atlantic, and lumber is an important export from both Quebec and New Brunswick, which latter greatly resemble the state of Maine in climate, topography, agriculture and in the importance which lumber and fishing assume.

Forests cover much of interior Newfoundland, and newsprint made from spruce and hemlock wood pulp is the most valuable export from that cold, foggy, and sparsely peopled island.

Alaskan Forests. The forests of Alaska are a continuation of those of British Columbia, and those of British Columbia are a continuation of those of adjacent parts of the United States. In the southern part of Alaska, especially on the rather narrow Pacific Slope, there is heavy rainfall with a dense stand of good western hemlock, Sitka spruce, and cedar which fortunately is owned by the United States Government. The Tongass National Forest in southeastern Alaska and the Chugach National Forest along Prince William Sound contain 87 billion board feet of timber, three-fourths of which is within 2½ miles of tidewater and which some day may be cut under governmental control.[13] In the interior of Alaska along most streams is to be found some good timber, which is used as fuel and building material in the small permanent communities and which long has served as fuel in the operation of river steamboats and for building cabins and as fuel by hunters, fishermen, miners and prospectors for gold. The large and dry inter-stream areas of the interior, however, support only a stunted and sparse

[13] It is estimated that the Tongass Forest under scientific management can produce not less than 1,500,000 cords of pulpwood annually in perpetuity that would yield 1,000,000 tons of newsprint paper, or about one-fourth of the annual newsprint requirements of the United States.—National Resources Committee, *Regional Planning, Part VII, Alaska, Its Resources and Development,* Washington, December, 1937, pp. 100-101.

tree growth, while the bleak tundra of northern and western Alaska has no trees at all.

5. *Forest Policy in the United States and Canada*

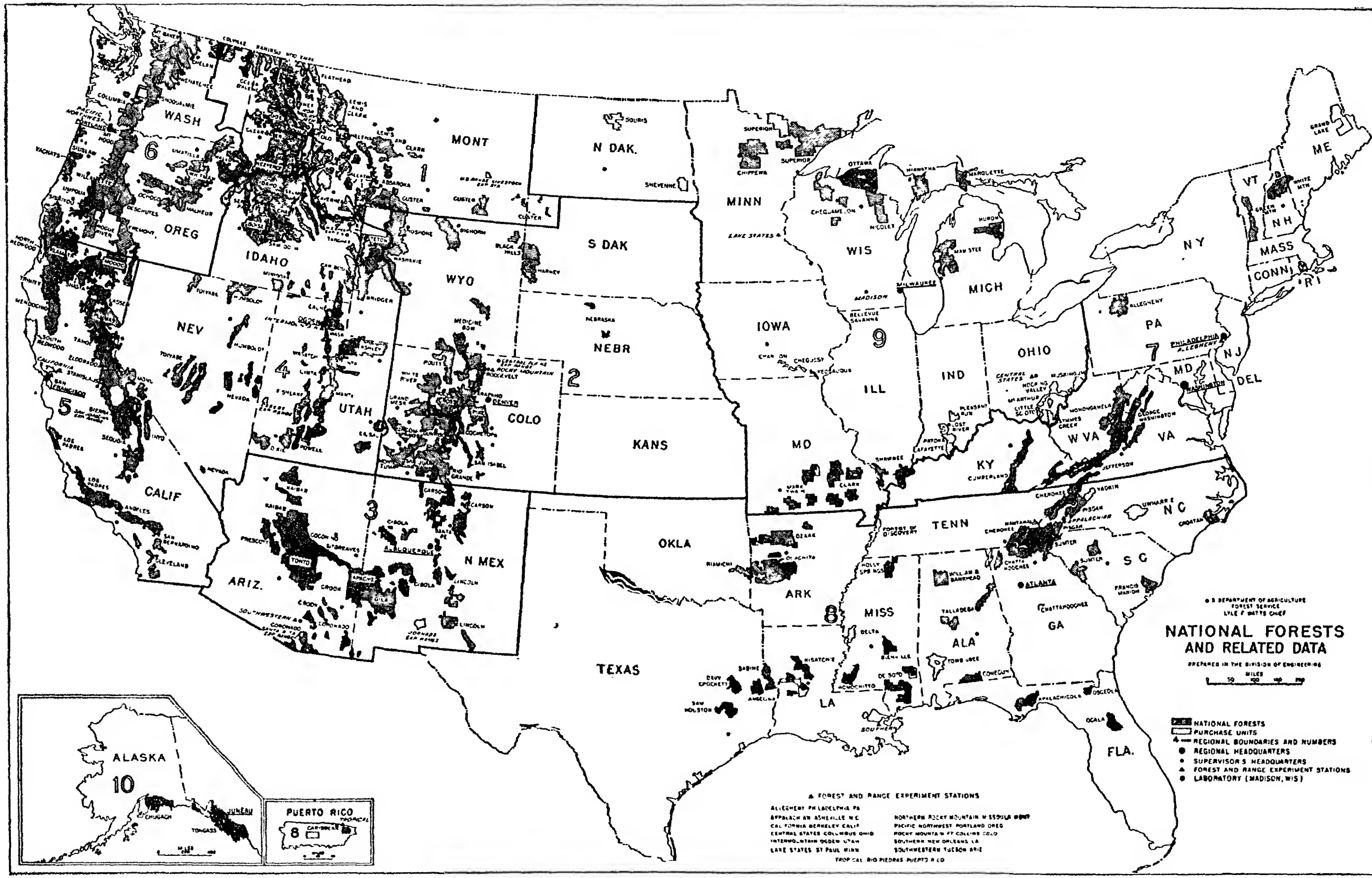
The European experience of deforesting, timber scarcity and the resulting soil loss, tree planting, and forestry has at last been heeded to a slight extent by the United States, especially since the rising price of lumber has called the attention of all classes to the impending scarcity of timber. Forest depletion received its first check in 1905 when the United States Forest Service was established and forest reserves, now called national forests, were placed under its management. The first national forests were set apart on government land that was unfit for agriculture but which had trees, and since then the government has greatly increased its forest holdings through land purchase. In 1943 the Forest Service administered 160 national forests covering 178,200,000 acres and containing about one-fourth of the nation's standing timber. The area of these national holdings exceeds that of New England, New York, Pennsylvania, Ohio, Indiana and Virginia. As the accompanying map (Fig. 351) reveals, the great bulk of our national forest land is located in the Rocky Mountain and Pacific Coast states.[14]

The national forests of Idaho alone cover 31,250 square miles, an area one-half as great as New England. Many of our states also own timber lands, but some of these are cut-over and burned-over tracts which have reverted to the state because no one will pay the taxes.

The United States Forest Service, besides the all-important function of fire protection, manages the cutting and reforestation of the national forests in a scientific manner. We may expect a steadily increasing output of lumber from this source, chiefly by the sale of full-grown trees to sawmill owners under conditions of cutting that will not destroy the young trees. For example, the Forest Service opened up for sale and development a tract of 550,000 acres in eastern Oregon, estimated to contain 7 billion feet of mature saw timber. The cutting of this timber is so hedged about by thrifty rules that instead of wholesale destruction of old and young trees alike, the timber trees will be removed carefully and the saplings safeguarded, so there will be a permanent yearly supply of 50 to 60 million board feet from that forest.

Not only does the Forest Service permit the selective cutting of timber on a sustained yield basis in our national forests, but it allows livestock to be grazed where trees are large enough not to be damaged, it helps to maintain animal and fish life, and it develops recreational facilities for the public. Wherever the government has been able to obtain control of critical watershed areas, a dense forest cover is maintained in order to stabilize stream flow, a service of great value to irrigation farmers, hydro-electric plants, municipal water-supply plants, navigation interests, and often many thousands of people downstream that would suffer from the ex-

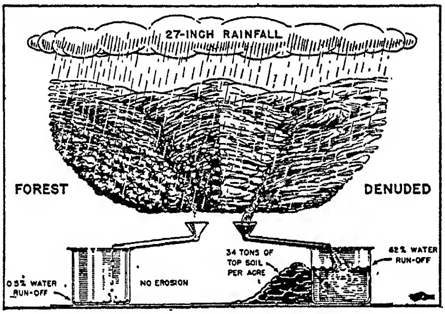
[14] In 1943 the distribution of land under Forest Service administration in millions of acres was as follows: Alaska—20.8, Idaho—20.0, California—19.4, Montana—16.3, Oregon—14.3, Colorado—13.7, Washington—9.6, New Mexico—8.8, Wyoming—8.6, all others, 36.7.



The most surprising thing about this map is the appearance of national forests in Iowa, Illinois, Indiana, and Ohio. The steady advance of national forests in the eastern half of the country as well as the western half is a good thing for the permanence of the United States. Too bad it began so late. Agricultural experts have recently reported that 2,500,000 acres of injured land in Illinois have been cleared and should be replanted to forests.

tremes of drought and flood (see Fig. 352). Wisely the Forest Service makes every effort to protect the forest against fire.[15]

Canadian Policy. In Canada, as in this country, the public forest lands are well managed, the government pursuing a policy of licensing timber-cutting rights, mining, water-power development, and



This diagram contains the record of a particular flood, the "Yazoo Flood, 1931." Contrast between water loss and soil loss on forest (0.5%) and bare land (62%) can be easily compared by a careful examination of the lower part of the figure.

grazing, hunting, and fishing privileges. About 90% of all forest land in Canada, excepting the Maritime provinces, belongs to the Crown, and in this vast public domain the vicious cycle of cut, slash, fire, and land abandonment has not been allowed to run its dismal course. On privately owned lands, however, Canadian lumbermen have pursued the virgin forest westward just as ours have done, and today most of the dominion's lumber is produced in British Columbia, most of the remainder being cut in Ontario and Quebec. In the vast expanse of Canadian forest the greatest of all difficulties is fire.

Americans and Canadians Face a Problem. Wherever private enterprise and cut-throat competition prevail, the evolution of forest history in most nations has been marked by three successive epochs: (1) wanton exploitation, forest cremation, and profligate waste;[16] (2) dwindling supplies of local timber and increasing imports from other lands; and ultimately (3) reforestation, conservation, and greater social control of forests.[17] In this country, after much talk and some work, our northeastern and Lake states are beginning to enter the third phase of forest history.

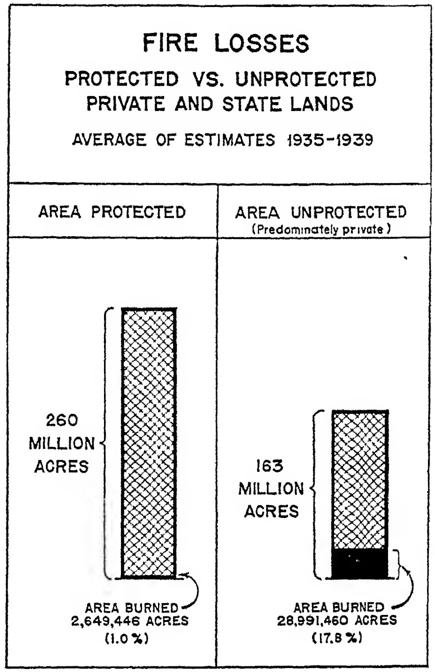
Just as the proverbial bird in the hand is worth two in the bush, so American lumbermen throughout the past have found it expedient to cut their timber and reap their profit as soon as possible. This premium on haste and waste has been largely the result of the ever-present danger of fire, heavy taxes on forest land, high interest rates and the burden of a large capital investment with no financial return until the timber

[15] About 17% of 141,000,000 acres of forest land without fire protection in the United States in 1941 was burned, while less than 1% of 436,000,000 acres of protected land suffered from fire. Fires in the national forests are reported by men stationed in high watch towers and by airplane patrols. Picks, shovels, axes, saws, and gas engines with hose are standard fire-fighting equipment. When a serious fire occurs, trees are felled and removed, and as much slash and debris as possible are removed or covered with dirt, thereby creating an empty lane or stop-gap in the path of the approaching fire. If the wind shifts and blows toward the approaching fire, a second fire may be started to burn out a lane in the path of the main conflagration.

[16] Countless seedlings and immature trees were destroyed in logging operations, and the land was often left littered with slash, a prime fire hazard. Even today wood waste in the United States is prodigious, for only 24% of the wood in a forest is actually converted into useful products, the remainder being lost through forest fires, disease, and logging and manufacturing waste.

[17] For an analysis of the role of the forest in a profit and a welfare economy, see Erich W. Zimmermann, *World Resources and Industries*, Harper & Brothers Publishers, New York, 1933, pp. 400-425.

is cut, the existence of an "unlimited" supply of timber and the uncertainty of future demand, and a pathetic general lack of understanding of forest resources and forest problems. In pitifully few instances have American lumber producers found it "worth while" to spend the time and money to make full use of the many products and by-products of wood and to cut timber selectively as a perennial harvest instead of stripping and abandoning the land.[18] Society must pay for the lumbermen's expedient and tragic philosophy of cut out and get out. The time may not be far distant when we will be obliged to pay as much attention to lumber growing as we do to wheat production or cattle raising. At present we are cutting timber at least twice as fast as we are growing it, which is indeed the handwriting on the wall. Do we care enough about the coming decades to read it?



The vital comparison is contained in the bottom figures. Since it takes trees some decades at best to become lumber, there appears to be no chance whatever for the unprotected areas to make lumber, unless it be that a lot of the unprotected land is repeatedly burned, as is a piece owned by the senior author of this book. It is a fairly typical piece of Appalachian mountainside. When he bought it forty years ago, he was told that it had been burned every few years for the forty years before that. It has been burned every few years during the past forty years, last fire, 1943. No piece of timber on it ever got any larger than a man's arm before another fire came along. Much timber land can only be protected in large blocks where owners cooperate effectively. This geographer's piece of land was not so situated. Appalachian land owners are famed for individualism, not capacity to cooperate.

6. *The Intensive Utilization of European Forests*

Comparison of European and American Timber Conditions. Europe, having four times as many people as the United States and Canada, and having been much longer occupied by a large population, has very different forest conditions. The American settlers found a continent covered with the forest growth of centuries which they have cleared to get at the earth in desirable localities and have elsewhere cut recklessly and with no regard to the future. While a scarcity threatens the United States, Europe has long felt it in the form of high prices, and is raising timber as carefully as she raises food. In western Europe the annual timber consumption per capita is only about one-eighth that of this country. Between

[18] For years one concern at Crossett, Ark., has found it profitable to practice scientific forestry on a tract of 400,000 acres.—See J. Russell Smith and M. Ogden Phillips, *North America,* Harcourt, Brace & Co., New York, 1942, pp. 285-286.

1906 and 1941 the use of timber in the United States declined from 525 to 246 board feet per capita. That is a simple fact, but it cuts deep. Indeed, it is one of the most significant economic occurrences of the century. It will continue.

The burner taking care of excess wood waste at a sawmill. Yes, we are still doing it. Photographed March 28, 1944, Washington County, Oregon.

This European economy involves many practices unknown in new forested countries. The American people annually destroy tens of millions of barrels, boxes, and crates that often are used but once, these containers being made of sawed lumber with all the waste this involves. In Europe packages are often used repeatedly and are very often baskets made of round or split twigs of willow which is grown for the purpose. The trees are planted in wet ground and repeatedly cut off when 5 or 6 feet high so that the stubby trunk with its great load of long twigs yields repeated harvests of basket material. Reeds resembling bamboos are also planted in the south of France and other European localities for package material. Frame houses have been built by hundreds of thousands all over the United States and Canada, while many people in central Germany never in all their lives saw a frame house. It is decidedly cheaper there to build one of

TABLE 20

PER CAPITA ANNUAL TIMBER CONSUMPTION IN EUROPEAN COUNTRIES, 1913 AND 1928–29 *
(In equivalents of standing timber)

	Saw timber,† cubic feet		*All timber, cubic feet*	
	1913	*1928–29*	*1913*	*1928–29*
Finland ‡	48.0	102.4	227.4	245.8
Latvia ‡	35.3	51.2	70.6	99.6
Estonia	35.3	38.1	70.6	98.2
Switzerland	16.2	19.4	31.1	36.4
Czechoslovakia	14.1	18.4	26.5	28.6
France	10.6	11.3	26.1	26.8
Poland	10.2	10.2	20.8	21.9
Great Britain	20.1	20.5	20.8	20.8
Sweden	72.4	64.6	185.0	162.8
Norway	55.1	37.4	116.5	71.3
Austria	16.6	18.0	40.6	37.1
Denmark	30.0	24.7	38.8	32.5
Germany	21.9	20.8	37.4	34.6
Lithuania §	17.7	8.5	35.3	16.6
Belgium	25.8	23.7	32.5	30.0
Netherlands	20.8	19.4	23.3	21.5

* Latest information available from U. S. Forest Service.

† Saw timber includes all classes of wood except firewood.

‡ Large apparent increase in saw-timber consumption in Finland explained by better statistics in 1928–29.

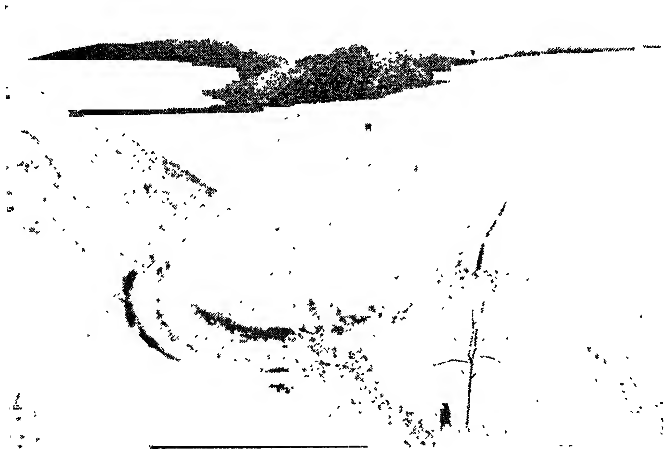
Part of increase in Latvia also results from better statistics.

§ Abnormally low consumption in 1928–29 due to disturbed conditions.

brick, stone, or plastering put upon a wooden framework. This framework is often of unsawed poles made from small trees, rather than the sawed material from large trees as in America. Reeds from the stream bank often replace in Germany the plastering lath used in America. This house made of reeds, poles, and plaster illustrates Europe's economy of wood. In forested mountain districts the European often uses wood as shown by the well-known Swiss chalet. This form of house seems to be a mountain institution, as it exists also in southern Asia Minor and on the southern slope of the Himalayas.

In Europe, particularly in Germany, intensive use is made not only of wood but of its various derivatives. Some 500,000 European motor vehicles are operated with charcoal-gas generators. During World War II German armies were clad in wood wool and were fed on the meat of pulp-fed cattle and on supplementary protein rations derived from wood. Many motor trucks were lubricated with tree-stump oil, and they rolled on synthetic rubber tires made from alcohol obtained from wood. So numerous and useful are the by-products of wood that the Germans often refer to wood as the *universalrohstoff,* or universal raw material.

European Timber Markets and Exporters. All Europe north of the Mediterranean slopes is naturally a forest country. In England, however, only 5.4% of the land remains in forest. The needs of tillage have not caused such complete clearance of the North Central Plain which reaches from northwestern France through north Germany and central Russia to the Urals. There are considerable areas of sand suited to little



The Schwarztaal Valley, near Bad Blankenburg, in Thuringia—a well-known health and recreation resort in Germany. The Germans have made sugar and other foodstuffs as well as many industrial raw materials from wood and the use of firewood is strongly discouraged. The well-kept forests of Germany are carefully used for health centers, recreation centers and hunting.

In 1929, the senior author drove in an automobile from Copenhagen to the top of the Alps, and in that time saw evidence of only one forest fire, covering about ten acres, and nowhere a single gully.

but pine forest. Holland 8% forest, Belgium 18% forest, and well-tilled little Denmark 8.2% forest have put their arable land to the plow and must import nearly all their timber. Only eight countries in Europe have a surplus, namely, Finland, Norway, Sweden, Russia, Austria, Yugoslavia, Poland, and Rumania. Norway, Sweden, and Finland are, like New England and Canada, glaciated, mountainous, populated only in spots, and with a small proportion of their land good for anything but the growth of trees or forests, which assume a very important place in the foreign trade of these countries. In Norway, 71% of the land is unproductive, 24.7% is in forest, and but 3.5% is under cultivation, and forest products make up over 25% of the exports. In Sweden, 56.6% of the area is in forest. As in America, the forests of Canada extend east and west across the continent, so in Europe the forests of Norway, Sweden and the Baltic States are continued eastward across Finland and north Russia to the Urals and onward across Siberia to the Pacific.

Thrifty Finland, with 14.7 acres of timber for every inhabitant, now rivals Sweden and northern Russia as the great commercial wood source of Europe. More than half her surface is covered with forest, chiefly spruce and pine, but in the seventeenth century, forests of larch were planted. Now each spring, with the melting of the snow, the Finnish and Swedish streams carry down their burden of logs as do the streams of New England and Canada, and upon the melting of the fields of ice in the Baltic whole fleets of tramp ships hasten to the Gulfs of Bothnia and Finland

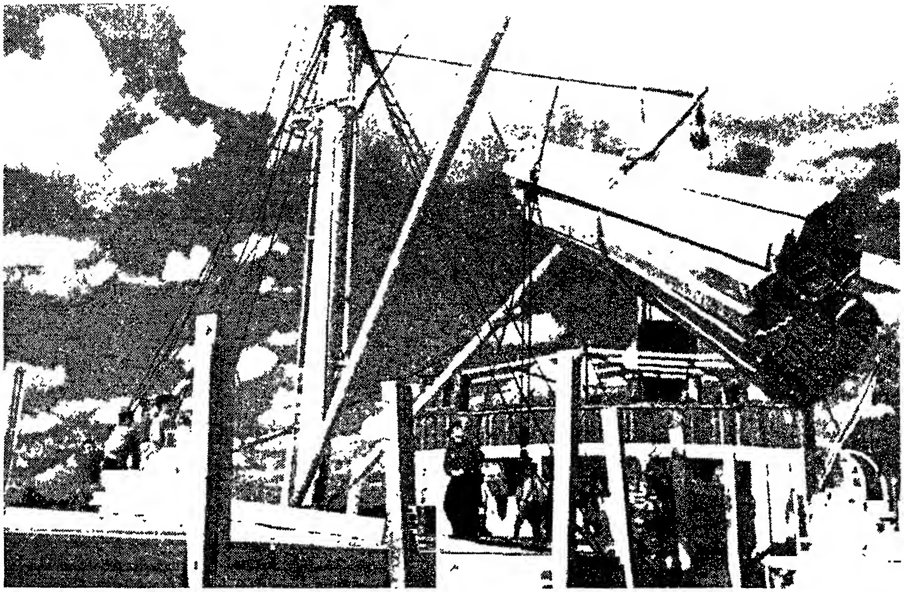
TABLE 21

FORESTS BY CONTINENTS AND SELECTED COUNTRIES *

Area	*Forest areas, million acres*	*Ratio of forest to total land area, %*	*Forest area per 100 inhabitants, acres*
Asia	2,096	21.6	240
South America	2,093	44.0	3,245
North America	1,444	26.8	998
Africa	797	10.7	560
Europe	774	31.1	170
Australia and Oceania	283	15.1	3,470
United States	550,000	28.9	520
Canada	596,746	25.0	8,230
United Kingdom	3,315	4.3	10
Russia (European)	440,000	38.7	440
Siberia	1,083,500	30.5	7,530
France	24,420	18.4	60
Germany	30,905	23.8	50
Czechoslovakia	12,354	34.3	90
Rumania	21,758	27.8	120
Poland	21,881	22.8	90
Italy	14,252	18.1	40
Spain	16,886	13.9	80
Denmark	872	8.2	30
Norway	17,037	21.4	650
Sweden	55,550	54.8	960
Finland	49,410	60.0	1,470
Hungary	3,148	14.0	40
Yugoslavia	17,258	25.2	120
Netherlands	640	8.0	10
Portugal	5,000	22.0	80
Switzerland	2,320	22.7	60
Japan (proper)	46,602	47.9	80
British East Indies	40,504	82.8	4,550
China	190,000	6.9	60
Brazil	1,000,000	47.5	3,280
Uruguay	1,070	2.3	70
French Guiana	21,000	98.0	42,000
Union of South Africa	1,511	0.5	25
Egypt and the Sudan	7,000	0.8	40
New Hampshire	3,602	62.3	813
California	33,000	33.1	962

* Mr. Sparhawk confirms this table as being essentially accurate for 1945.

Source: Raphael Zon and William N. Sparhawk, *Forest Resources of the World*, McGraw-Hill Book Co., Inc., New York, 1923.



Sovfoto

Lumber from the Soviet sub-arctic forests swings on shipboard for use in a nearly treeless foreign land, not far from the English Channel.

to load cargoes of lumber, mine props, pulp, and paper from the many sawmills, paper mills, and log drives. Wood, pulp, and paper furnish 80% of the exports of Finland and promise to hold this leadership.

The largest coniferous forest in Europe today stretches across Russia north of 60° N. Lat. and contains a splendid stand of Norwegian spruce, Scotch pine, fir, and larch, with some birch, alder, and willow. In this cold region tree growth is slow, 18-inch logs often being cut from trees 150 to 175 years old. During the summer millions of logs are rafted down the Severnaya Dvina, Onega, and Mezen Rivers to the White Sea. Archangel (pop. 281,000) is the largest sawmill center in all of Russia and a great lumber exporter. Although the White Sea is frozen from November through April, powerful icebreakers maintain an open channel for shipping throughout most of the winter. Considerable lumber is also shipped through the Baltic and White Sea Canal. As Scandinavian timber supplies have diminished, the reserves of northern European Russia have increased in commercial importance, Great Britain importing more lumber in recent years from Russia than from all other countries combined.

Forest Policy in Central and Northern Europe. The scarcity of wood, that has caused the European nations to preserve their timber and practice forestry, has often driven the federal, state, and municipal governments into the lumber business.[19] Nearly all the governments own forests and care for them as part of their administration. As a result

[19] Poor or expensive transportation facilities of the eighteenth century forced Europe to governmental and municipal timber operations. Europe was then in the same scarcity that we now face, and since they could not haul it they started to grow it—luckily for their grandchildren.

France has 19% of her area covered with forests, Germany 26% (1938) and Switzerland 25%, and in populous Saxony the forest area amounts to 25%. In U.S.S.R., it is 44%. During the disturbances of the French Revolution, forests were cut from some of the mountains of France so that the earth, exposed to the erosion of rainfall, was washed away to the destruction both of the mountain soils and the valleys below, upon which the rocky earth was piled. After the end of the Napoleonic Wars, steps were promptly taken to replant these areas wherever possible.

In France various governmental units now own and operate over 37% of the forests. Within a century an area of shifting sand dunes and marshes in the southwest of France, twice as large as the state of Delaware, has been turned into a profitable pine forest yielding rosin, tar, pitch, turpentine, and other products. These are made from small trees which are bled to death in the process, and the trunks sent to Great Britain to serve as mine props. This thinning promotes the growth into sawlogs of the trees that remain.

Scientific Forestry in Europe. It is to Europe that we must go for the best examples of well-managed forests that are producing their maximum output. There we can learn to make our own forests permanently meet our needs. In densely peopled localities the trees are often planted as thickly as hills of corn in the United States, which is about 4 feet apart. When the trees are 1½ to 2½ inches in diameter they are cut for use as bean poles, hop poles, fence palings, etc., while the later thinnings furnish poles for firewood and many other uses, including part of the framework of the plaster house. At the end of one hundred years or more, after many thinnings, the forest contains only big trees that can be sawn into boards and building timber, after which the forest is replanted, to go through the same cycle of harvests. Many German and Swedish towns own adjacent forests which are carefully managed and furnish the towns with a large part of their revenues.

There are several different systems of handling forests in Europe each suiting some particular kind of forest or condition of marketing the product. But even under scientific forestry France, Germany, and Switzerland with their relatively large percentage of well-managed forests are not able to supply their own needs even with their small consumption.

The importance of forests and forestry is shown in the mountains of Switzerland and the Black Forest district of south Germany, where wood carving is an important industry of the peasants in the winter season, and their wooden toys and curios are exported throughout the western world.

The Forests of Mediterranean Countries. In Europe, as in America, the coniferous trees comprise the bulk of the northern forests while the oak comes from lower latitudes, growing in Spain, Italy, Hungary, and the Balkan Peninsula. In Yugoslavia, the oak trees on the high lands comprising most of that country furnish in their acorns one of the leading crops—harvested by swine.[20]

[20] Mast feeding of hogs has been practiced in many European countries for centuries and is common in many of our southern states.—See Earl B. Shaw, "Geography of Mast Feeding," *Econ. Geog.*, vol. 16, July, 1940, pp. 233-249, and J. Russell Smith, *Tree Crops,* Harcourt, Brace & Co., 1929.

There are practically no forest resources of importance along the southern or western shores of the Mediterranean, and the dry summer of Spain, Portugal, Italy, Greece, and Turkey limits tree growth to the mountains with their greater rainfall, and leaves all these countries with an insufficient supply of lumber. The houses are almost invariably built of earth materials, mostly stone and plaster and, as these countries are barren of coal, and populous with poor people, many of the inhabitants suffer keenly from cold in the winter season.

If you want to shiver go to "sunny" Italy or Spain in the winter. Italy, having, like France, lost good lands from unwise deforestation, has also been planting forests. The soil destruction in these European countries is as nothing in comparison to that which has occurred in North Africa, Palestine, Syria, and Asia Minor, where many districts that were fertile and populous in Roman times have been reduced to deserts through neglect, forest fires, overpasturing, and reckless tree cutting by ill-governed peoples. It is said that there are more Roman ruins west of the Jordan than in all the rest of the world together, and where there were once populous cities, there is now no support for tillage and a very considerable territory east of Antioch which was populous when conquered by Pompey and ruled by Caesar is said to have the soil so thoroughly washed away that there is nothing but bare rocks. Some of this desolation has probably been caused by the changes in the rainfall, denudation of forest and grass has been a more certain factor. Page the camel and the goat.

Cork, the principal forest export of southern Europe, is the tough outer bark of a kind of oak growing upon the highlands of Portugal, Spain, southern France, and the mountain ranges of North Africa running through Morocco, Tunis, and Algeria. The bark can be stripped repeatedly from the trees at intervals of a few years. The chief export comes from Spain and Portugal and a smaller amount from Algiers and Morocco. The cork oak grows without cultivation on rough mountainous land, and it covers large areas in the northeastern part of Spain near and upon the Pyrenees Mountains in Catalonia where the best quality of cork is produced. It is also largely grown in the province of Andalusia and Estremaduro in southwestern Spain and in the adjacent parts of Portugal. The Spanish cork exports exceed 24,000 tons and are the chief forest export of this country. The cork forests cover 1,300 square miles (832,000 acres) in Spain and also much of Portugal. In Algeria the area is 50% greater, and the output is 50% less. Some cork is also grown in the south of France. The cork oak has been planted experimentally in California and some of our southern states; as yet our entire supply of cork is imported, but we can grow it.

7. Forests in the Temperate Lands of Asia and the Southern Hemisphere

Japan's Forest Industries. Japan is a country which from necessity takes excellent care of its forests. Because of the hilly nature of the country and heavy rainfall, forests cover a large portion of the country, much larger than in moun-

tainous Switzerland. Having a meager coal supply, the forests have up to a recent time furnished all the fuel as well as building material of a dense population, Japan proper now having 73 million people on 149,000 square miles. The United Kingdom with 48 million people on 94,000 square miles has long ago used up practically all her forests, and must now import timber, chiefly from Russia, Canada, the United States, Finland, and Sweden. Since her industrial revolution, Japan has opened up previously unused oak forests on the colder and less intensively used north island, Hokkaido, but this does not seem to meet her growing needs, as for some years Japan has imported increasing amounts of timber from the Pacific coast of Canada and the United States. It is possible, however, that Asia will supply most of Japan's timber. The immediate cause of the Russo-Japanese War was a dispute over certain timber concessions along the Yalu River between Manchuria and Korea. Manchuria and Korea have extensive forests, but most of them will be inaccessible until American methods of lumbering shall be introduced and new railroads built. These things were in the Japanese plan. Now—?

In bamboo, lacquer, and camphor Japan has three forest products that well illustrate the genius of Oriental people. The bamboo is probably the most important Japanese tree. It is planted and cared for like a field crop and fills a multitude of uses. It is said that the ingenious Japanese can build with it an entire house—framework, floor, walls, and roof—while its large joints serve as buckets and other utensils in great variety, and the young shoots serve as food. The lacquer, that beautiful varnish which we see on the glossy lacquer ware, is made from the sap of the lacquer tree. The camphor is a kind of resin distilled from the wood of the camphor laurel tree which grows throughout the warmer parts of the Japanese Empire, but the trees have been so vigorously cut that the greater part of the world's supply of natural camphor has come from Formosa for some years. The Fukien province of China, the islands of Shikoku and Kiushu in Japan, Cochin-China, Sumatra, Java and Borneo also contribute one or more kinds of camphor to the world's market.

It has now been found that there is more camphor in the leaves and twigs than in the trunk, so that the practice of chopping up the whole tree is unnecessary. In Florida where the camphor tree grows well, specimens attaining a diameter of four feet in thirty years, clippings of leaves and twigs are made once a year, and the crude gum is produced on a small scale from them by distillation. Thus does man change from a hunter and destroyer of wild products to a cultivator of crops. In the United States most camphor is used in the manufacture of celluloid and other synthetic plastics. In 1939 we imported 1,157,000 pounds of natural camphor from Japan and 528,000 pounds of synthetic camphor from Germany, while during the war we relied upon synthetic camphor derived from the turpentine of our southern pine trees. In the future—?

In like manner the bamboo has been transplanted to our own South Atlantic and Gulf states, where small groves are thriving as well as in their native Japan

beria west of Lake Baikal the forest belt narrows but it reaches clear over to the Urals, an area of vast extent situated in admirable relationship to the agricultural belt to the south of it.

Now that the airplane is enabling ships to find their way through the Arctic with greater ease, there is new possibility of marketing Siberian timber.

Forests of the Southern Hemisphere. The temperate forests of the southern hemisphere are but pygmies in size when compared with those of North America and Eurasia, a contrast resulting from the fact that (1) the land area of the South Temperate Zone is much smaller than that of the North Temperate Zone and that (2) most land south of the Tropic of Capricorn is too dry for good tree growth.[22] While forests in the temperate lands of the southern hemisphere are of local importance, they supply a very small part of the world's timber.

The largest, best, and most accessible softwood forest in all of South America covers about 100,000,000 acres of rolling uplands in the states of Paraná, Santa Catarina, and Rio Grande do Sul that lie in the southern and coolest part of Brazil. This forest, with about 800 billion board feet of timber in reserve, contains large and unmixed stands of excellent Paraná pine, many of the trees ranging from 80 to 120 feet in height. Modern sawmills, equipped with American machinery, are now in operation, about two-thirds of the lumber being used in Brazil, especially in the more populous states of São Paulo and Rio de Janeiro, the remainder being exported chiefly through the port of Paranaguá to the treeless pampas of eastern Argentina and Uruguay. The temperate-zone forests of Argentina lie at the base of the Andes in Patagonia, they lack adequate transportation facilities and are little used, for they are inaccessible to the markets of the eastern pampa where three-fourths of the nation's people live. Hence, Argentina is the leading lumber importer of South America, obtaining its supply from Brazil and the United States. In Chile about 700 small sawmills operate in the cool, moist, and rugged forest land south of Puerto Montt. Only about one-eighth of a forest area of less than 39,000,000 acres contains commercially valuable timber, which is being used more and more since Chilean tariffs have reduced lumber imports from the west coast of Canada and the United States.

Since less than 1% of the Union of South Africa has a forest cover, mainly along the south coast, the nation is vitally dependent upon lumber imported from our southern states and from the Baltic countries. The chief forest export is wattle bark, which yields an extract used in the tanning of leather. In the southeastern and southwestern parts of Australia and on the island of Tasmania are hardwood forests that cover about 1% of the nation's area. Each year Australia must import about

[22] Look at a globe, notice how South America and Africa taper off to the south, and see how little of the world's land area lies south of the Tropic of Capricorn. Compare the natural vegetation and rainfall maps that are drawn on homolosine equal-area projections in *Goode's School Atlas.* Observe the location and size of the Atacama, Kalahari, Gibson, and Great Victoria Deserts. Note the areas in the South Temperate Zone that will support only sagebrush, thorn scrub, and prairie grass and the much smaller areas where moisture permits forest growth.

$10,000,000 worth of softwoods from the Pacific coast of Canada and the United States and from New Zealand. Among Australia's limited forest exports are two hardwoods that are unusually resistant to moisture, the ravages of insects, and decay: karri wood that is used to pave bridges and streets in western Europe and jarrah wood which is commonly used for piles in wharf construction in many a seaport throughout the world. The forests of New Zealand are much better than those of Australia, containing various pines and the well-known gum-bearing kauri, but rapid cutting threatens the existence of the lumber industry, and only one-fifth of the original stand of timber now remains.

8. *The Tropic Forest and Its Products*

The Relative Unimportance of Tropic Forests. The Torrid Zone contains a larger area of forest than does the temperate zone. Tropic woods are in great variety and many are of surprising beauty and hardness, but the forests upon the whole are very much less valuable than those of the cooler north with its less favorable conditions for the growth of vegetation. The relative uselessness of the tropical forests is due to poor quality and inaccessibility. Many trees of the tropic forests are crooked and useless for lumber. They are often worthlessly soft and weak, and the good ones are almost always mingled with many other species. A volcanic cone stands in the plain north of Manila. Botanists report more species of trees growing on this lone mountain than can be found in all North America. The boast of many varieties of woods in a tropic area, while not untrue from the standpoint of a systematic botanist, is the vaporing of an economic tyro. This mixture of species is a striking and important contrast to the practically solid stand that exists in the pine or spruce forests of Maine, the pine of Mississippi, the fir of Washington, the cypress of Louisiana, or the oak of West Virginia. Those who gather tropic logs usually find but one tree of a kind in a place, surrounded by hundreds of useless specimens of other varieties.[23]

To make matters worse, the heavy rainfall and the heat produce such a wealth of bushes, small trees, and vines that in many areas a man can only force his way through by first cutting a path. Thus the machete, a long-handled knife, is the most universal tool possessed by the inhabitants of many tropical countries. With it they cut paths through the forest in which each tree is often bound by creepers to a dozen others so that the felling of one tree is a most difficult process. As the jungle is often swampy, it is evident that a wagon can rarely enter to carry logs because the wheels would sink into the soft earth even if roadways could be cut. The nearest approach to the northern blessing of snow with its sled transportation is the annual floods of the rainy season, which permit the floating out of those logs which grow on overflowed land and are light enough to float. Those that are heavier than water, and most of the tropical cabinet woods with their great strength and beauty are

[23] The mahogany tree lives by itself, two trees to an acre being a liberal estimate. More frequently only one tree will be found in a larger stretch of territory.

heavier than water, must rot where they grow, or be dragged out at great expense. Consequently, the chief timbers exported from the tropics are the buoyant mahogany and Spanish cedar of which the United States imported $2,000,000 worth in 1940, chiefly from British Honduras, while all other cabinet woods imported were not one-fifth as valuable. One vast belt of solid green girdles the earth wherever the land emerges from the equatorial sea, yet this equatorial forest has thus far been of less use to our world trade than if it were a desert with an occasional oasis.[24]

The Philippine Islands provide a good example of the low commercial value of tropic forests. The botanists tell us that more than a hundred species of useful woods are to be found in the islands, which are largely covered with forests belonging to the government. It is not the number of species, but the goodness and cheapness which make them valuable. Nine species of trees, namely, yellow pine, Douglas fir, white pine, hemlock, western pine, spruce, cypress, the oak, and maple, have furnished 95% of American timber and made the United States the greatest timber producer and exporter in the world. Despite their riches in forest area and number of varieties, the Philippine Islands have only a small export of cabinet woods.

The Woods Exported from the Tropics. Mahogany, the most important wood exported from the tropics, is hard,[25] strong, taking a beautiful finish, and is much prized for furniture and interior work. It is light enough to float and valuable enough to be hauled out of some locations where there are no floods to float it. The best mahogany is shipped from Haiti and the Dominican Republic, while other mahoganies come from British Honduras, Mexico, Honduras, Cuba, and Brazil. The mahogany hunter, climbing one mahogany tree, looks across the forest to locate the next one towering above the level green, and then cuts his way to it. African mahogany, a slightly different species, is shipped in large quantities from coast ports between the Gold Coast and Cameroon in West Africa. The chief market for this wood is Liverpool, whither it is shipped in great logs and forwarded to the finer wood-working establishments of Europe and the United States. Spanish cedar, the second tropical wood in commercial importance, exists in many varieties, exported chiefly from the West Indies, and the Gulf coasts of Mexico and Central America. One of the chief uses for this soft light wood is the making of cigar boxes and pencils. The third of the tropic woods is the teak, a wood which resembles oak in its physical characteristics, but is much more valuable than oak for shipbuilding because, unlike oak, it contains an oily substance which acts as a preservative, and when in contact with iron causes it to deteriorate much less rapidly from rust than do oak and other woods. It grows in the forests of southeastern Asia from India to China and has been planted for tim-

[24] The tropic forest naturally runs through great variety of stand and condition in places where the rainfall varies from desert to 200 inches per year—open scrub, solid scrub, jungle (low forest tied together with creepers), and finally the rain forest, open beneath because the thick mat of the tops of tall trees smothers undergrowth. Any climate wet enough to make the rain forest makes also a good deal of mud.

[25] Mahogany is really an intermediate wood, being softer than oak, elm or even birch, but harder than yellow pine or Douglas fir. In strength and specific gravity tests it is almost identical with our red gum.

ber purposes in Java. The chief supply of commerce comes from Burma where it is floated down the Irrawaddy River to Rangoon, the Salween to Moulmein, and from Siam where the Menam River floats the valuable logs down to Bangkok for shipment. As Britain is the greatest shipbuilding nation in the world, she imports most of the teak.

Tropic Imports of Temperate Zone Woods. It is true that some tropical timbers have great hardness, strength, durability, and beauty, but many of them are so hard that tools will scarcely work them. Furthermore, their inaccessibility makes them as useless as the millions of tons of excellent building stone which lie valueless in the heart of every mountain region far from growing cities. Despite the riches of millions of square miles of jungle and forest lands, American lumber is imported by practically every tropical country in America and Africa, and occasional shipments go even to Asia and the East Indies. The rubber merchants of Pará or Manaos on the Amazon, desiring to build a warehouse, find it economical to buy the softwoods of the United States, into which they can easily drive a nail, instead of using the beautiful but hard cabinet woods in the forest that actually encroaches upon their building lots.[26]

Minor Products of the Tropic Forest. The tropic forest is more important for its minor products such as rattans and gums than for its wood. Of these minor products the greatest, rubber, greater in value than all the other products of the tropic forest combined, is left for another chapter.

It has migrated from the forest to the field. Closely allied to it from the botanical standpoint are many other gums which are produced from the dried sap of trees. The well-known "gum arabic" so commonly used as office paste has the useful quality of being soluble in water and is plucked from trees by natives throughout the half-forested belt that lies between the jungle and the desert reaches across Africa from Senegal to Ethiopia. It is also shipped from Somaliland, India, Australia, and South Africa.

Gums of another class known as copals are with difficulty soluble and therefore serve as the basis of varnish. They are produced by many trees, one, the kauri gum of New Zealand, is extratropical, being found in a fossil condition covered by the surface earth where it has dropped from kauri trees of past ages. It has been diligently dug for the last eighty years and is still being found, and small quantities are produced by the living forest. Other copals are dug from the earth in Madagascar, Zanzibar, and adjacent Africa, but the greatest center of shipment for these gums is Singapore, the Malay metropolis. Here also is gathered for shipment a large proportion of the world's rattan, the jointed stem of a creeping vine that runs for hundreds of feet through the tropic tree tops and helps to bind them together in the jungle mass. Properly split it makes the cane seats of chairs.

Nuts make an entirely different class of forest product and one of indefinite expansion. From Pará, Brazil, come the dark Brazil nuts with their triangle cross-section and rich white meat, said

[26] Tropic lumber trade was graphically illustrated by a ship unloading Texas pine lumber at Ciudad Trujillo (Santo Domingo) on to the dock beside piles of mahogany logs ready to go north.

to contain one of the four perfect proteins. They could apparently be produced (picked up) in indefinite quantities if desired. Other varieties of good nuts waste in the same forests. From Ecuador about 13,000 tons of tagua nuts (vegetable ivory) are annually exported to European and American button factories. This valuable nut, sometimes as large as a hen's egg, is the product of a palm that grows wild in most locations, sometimes yields thirty pounds of nuts and lives for fifty or one hundred years. The market is partially supplied by somewhat similar nuts from Eritrea and the Egyptian Sudan.

The importance of minor products in tropic forest economy is also shown by carnauba wax, which is obtained from the fan-like leaves of the carnauba palm and which is used in the manufacture of shoe, furniture, and automobile polish, electrical insulation, phonograph records, photographic film, and other products. Virtually all of the world's supply is produced in northern Brazil, chiefly in the states of Ceará and Piahuy. In 1940 Brazil's exports of carnauba wax were worth $8,471,000, or considerably more than the total value of its exports of timber and lumber.

9. *Naval Stores and Tanbark*

Important among the many minor industries of the forest is the preparation of naval stores, the name applied to turpentine and rosin, products of the sap of certain pine trees. Rosin is the product remaining after turpentine has been distilled from pine sap. More than half of the world's naval stores are produced in the longleaf and slash pine forests of the southeastern United States, Charleston, Savannah, Jacksonville, Pensacola, and Mobile, being important points of shipment. The production of naval stores, as formerly carried on in the southern United States, was very injurious to the forests. The sap gatherer made great wounds in the base of the tree from which in a few years it bled to death. During the process it was exposed to easy destruction by fire, and was easily overturned by windstorms. This wasteful practice has been replaced by a newer way of turpentining, known as the cup and gutter method which does not gash the tree so deeply and greatly prolongs its life and yield. Today much sap is also recovered from old pine tree stumps. Inasmuch as the slabs which are burned or wasted around many southern sawmills also contain large quantities of sap, as do the small branches and tops which are left in the woods, it is likely that the near future will see more economic methods of gathering naval stores. Some processes now in use take all this refuse wood, soak the sap from it for distillation and leave the pulp thus purified for making paper. The French gather turpentine much more effectively than we do. They use the method which our Forest Service is requiring in the national forests—"turpentine thinning." This means gradually bleeding to death the trees it is desired to remove, thus serving a dual purpose by using the wood of the exhausted tree. Such trees from France prop many a British mine.

Another industry which has caused great destruction of American forests is the gathering of bark for tanning. The chief bark trees are the hemlock and certain species of oak growing from Pennsylvania southward on both slopes

of the Appalachians. Millions of good trees have been cut down for their tanbark alone, the trunks being allowed to rot. This shameful waste of logs went on to some extent in the eastern country and also in California, where in the Coast Range there is considerable collection of tanbark from one of the western oaks that grows among the redwoods. The tanbark district of Wisconsin and Michigan (chiefly hemlock) is second to the Appalachian in output. More detailed information about this industry will be found in the chapter on leather.

10. Wood Manufactures

Rough and Finished Lumber. The manufacture of the heavy log into rough lumber naturally clings to the forest, although special conditions cause some export of logs, especially of such high quality woods as mahogany and walnut, which may be used for veneers. The further manufacture of lumber, usually carried on in planing mills where the rough boards are finished, tends to concentrate near the market in or near centers where building operations are largely carried on, since the rough lumber is more easily moved and stored than the easily injured dressed plank or the sash, doors, blinds, and special shapes that the planing mill turns out for the builder. For some years there has been a growing tendency to attach the planing mill to the sawmill. Slabs and small pieces can be made into sash and other things using small pieces.

Furniture. The same factors tend to locate furniture manufacture in great centers of consumption, especially in timber-importing countries. Thus London is both market for product and center for raw material because the imported wood is unloaded there from the ships. Owing to an early start when nearby timber supplies were abundant, and to very low freight rates since, we have had a furniture industry developed near the former area of wood supply in Grand Rapids and other towns in Michigan, Illinois, and Indiana. Today North Carolina leads in furniture manufacture, with High Point as the major center. This is a raw material location like Grand Rapids, and New York like London is also important.

The modern furniture factory in Grand Rapids, High Point, or elsewhere uses quantity production methods similar to those in use in the Ford automobile plant. Hand work is at a minimum and machinery does every possible part of the cutting, shaping, and assembling of parts. One may see ten thousand sewing tables going through the factory all at the same time, and all identical in wood, design, finish and workmanship. The "knock-down" system of furniture making, which has been extended to boats and even houses, has helped many such cities to maintain their wood-working industry even after the nearby timber supply has been exhausted. The expense of importing the raw lumber is balanced by the saving in freight. Furniture is expensive to ship, not so much because of its weight, but because of its bulk. "Knock-down" furniture can be taken to pieces, permitting economy of space in shipping. In this way the parts of boxes and barrels (called shooks) are shipped ready to put up.

The constantly increasing price of hardwood lumber used for making fur-

niture, fixtures, and cabinets has caused the substitution of much built-up lumber, usually made of three-ply veneer. Veneer is wood sliced into thin sheets like pasteboard or even like paper. Thus a fine hardwood log selected for beauty of grain can be used as the exterior finish for thousands of articles of furniture made of cheaper wood. In manufacturing this built-up material it is possible to utilize woods which heretofore have been practically valueless, owing to their tendency to twist and warp when sawed into lumber. The large increase in the manufacture of veneer and its use for cheap industrial purposes[27] is suggestive of the advancing economy of wood that scarcity and high prices are forcing upon us.

11. The Manufacture of Paper

Changes in Raw Materials. In 1840 when cotton, linen, and woolen rags were the chief dependence of the paper manufacturers, it would have seemed preposterous to place a discussion of the paper industry in a chapter dealing with forests and forest industries, but this is an industry which has been completely transformed by changes in technique, resulting in changes in raw material.

Some material for the easy recording of thought is important alike in industry, commerce, and civilization. It is one of the necessary bases of an elaborate culture. The inhabitants of Babylon, Nineveh and other cities of Mesopotamia wrote on clay tablets and baked them, making the clumsiest but most enduring of all books. The Egyptians made papyrus closely resembling paper by carefully pasting together the pith of a sedge-like reed of the Nile bank, which was carefully cultivated on large areas where now corn, cotton, and rice are grown. The Chinese discovered how to make paper. The art spread thence through central Asia to the Arabs, was brought by them to Spain, and became established in England in 1588. Without it the printing press would have been of little value, for the only alternative was parchment, made of sheepskins, much more durable than paper, but too expensive.

Paper was first invented by the wasps and hornets who still maintain the industry and defend the product. They use the same process now followed by man—macerating wet vegetable fiber and spreading it out thin to dry. Nearly all plants have cellulose fibers in them, and as indefinite numbers of vegetable materials will make paper, the actual choice of materials is decided by the relative quality and the cost. For two or three centuries cotton and linen rags were the chief dependence for paper making. In 1857 an Englishman invented a process of making paper from a tough grass called esparto, which

[27] With the improvement of veneer machinery and methods of drying, there has developed a large demand for veneers cut from cheap woods and used for packing boxes, berry cups, fruit baskets, veneer barrels, drawer bottoms, filling in three-ply lumber, glass backing, and novelties, such as butter dishes, wooden plates, and fancy confectionery packages. Waterproof plastics are opening for plywoods a new and promising expansion of usefulness, including roofing.

At Laurel, Mississippi, a plant uses another new process of great promise. Wood is chipped, put into a cylinder for a short time with steam at 1,200 lbs. pressure. Upon release of pressure the chips explode. The fibrous soupy mass is immediately pressed out into boards of any desired dimensions. The naturally adhesive lignin of the wood makes this new wood stronger than the old. This process is something to watch. It has interesting possibility of "alloys." Unfortunately sawdust will not absorb enough steam to explode.

grows well on arid, sandy, and rocky land and is found wild over large areas in the Barbary States of North Africa and in Spain. In less than 30 years after its introduction, it assumed an importance in English paper making greater than that of rags. By 1901 esparto was far outranked by the predominating wood pulp, which opened up to the paper industry a vast supply of materials at a relatively low cost. Various other fibers are used to a small extent, such as the bark of the baobab tree, which with long, strong fibers makes the exceedingly fine paper used for bank notes. The cotton stalk is full of fibers and some inventors are promising us that it will be an important material for paper.

In the United States wood comprises about 60% of the fibrous raw material used in paper manufacturing, and about 80% of this wood is obtained from yellow pine, spruce, and hemlock trees.[28] Fortunately paper can be reprocessed, and about one-third of the output of our paper industry is made of waste paper, which is used primarily in the manufacture of paperboard.[29] Linen and cotton rags still remain the best of all materials for making durable, high-grade writing and book paper.[30] Exceptionally strong paper bags are made from the jute of discarded burlap and the manila hemp of old rope. Of minor importance are straw and imported esparto grass.

The Manufacture of Paper from Wood Pulp. To convert wood into pulp, short logs may be ground into mush by huge power-driven grinding stones or the logs may be cut into chips which are cooked in chemical solutions that eliminate all woody substances but the cellulose fibers, the chief basis for paper manufacture. The fibers float in water which is kept at a uniform soupy thickness by stirring. For centuries paper making was a handicraft carried on by the paper maker and his family, who dipped sieves into vats of floating fiber and carefully lifted out upon the wire gauze enough fiber to produce a sheet of paper when properly dried. Now continuous process machines turn out more than 500 feet per minute and send it away from the factory in sheets often miles in length wound upon spools into rolls 3 or 4 feet in diameter. If the paper is to be used for writing purposes, the spaces between the fibers are closed by a process called sizing, which fills up the pores with material chiefly composed of china-clay, rosin, alum, or talc, a process that greatly adds to the weight of the paper. While the expensive hand method of paper making prevailed, its price was high, and demand for it small. The discovery of wood pulp and the invention of machines to turn out paper in quantity have made it cheap enough for a wide variety of uses.

Location of Paper Manufacturing. The manufacture of paper from wood pulp began in Europe in 1840 and in this country in 1865, wood pulp now being used to make the greater part of the world's paper.[31]

[28] Of 13,743,000 cords of pulpwood consumed in this country in 1940, 5,013,000 cords were yellow pine, 3,009,000 cords were spruce, 2,789,000 cords were hemlock, and 599,000 cords were poplar.—U. S. Dept. of Commerce, *op. cit.*, p. 827.

[29] Evan B. Alderfer and Harold E. Michl, *Economics of American Industry*, McGraw-Hill Book Co., Inc., New York, 1942, p. 251.

[30] The *New York Times* sells to libraries an expensive "rag edition" which, because of its durability, can be preserved as a record for posterity.

[31] The cheapness of pulpwood greatly depressed the trade in, and reduced the price of, esparto grass, which had been a staple export of many

Before the pulp era, our paper mills, like our woolen mills, had been clustered along small streams in the vicinity of centers of population. The great increase in the use of wood pulp for paper in the United States since 1890 caused the transfer of the center of the paper industry away from the market to the forest districts. Approximately two-thirds of the pulp mills of the country use water power because, when available, it is the cheapest source for the great amount of energy required to grind the wood into pulp. Relatively pure water is also a very important consideration, because the dirt of the water can adhere to the floating fibers and thus pass into the paper.[32] For some years the production of wood pulp was concentrated in northern New England and New York, but the industry soon became established in the Lake states and later in the Pacific Northwest, which has the greatest supply of wood and is deluged with water power. The northeastern states have a stand of spruce and hemlock second only to the Pacific Northwest, and in 1940 Washington and Maine led the nation in wood pulp production with about 30% of the total output. On the basis of value, New York, Wisconsin, Michigan, Ohio, Pennsylvania, Maine, and Massachusetts are the leading paper-making states, a leadership that reflects the importance of access to raw materials and power, nearness to market, and the impetus of an early start. Each year we consume in this country almost 250 pounds of paper per capita, and most of this paper, excepting newsprint, is manufactured in the United States. American paper mills, however, particularly those in the East, draw heavily upon Canada and Scandinavia for raw material. In normal years about one-half of the wood used by American paper mills is imported, 20% in the form of wood pulp, 20% in the form of pulpwood, and 10% in the form of paper.[33]

Massachusetts leads in the making of rag and fine writing papers, for the manufacture of which Holyoke, on one of the falls of the Connecticut, is the most specialized center in the United States. Pennsylvania, Ohio, and Michigan also rank high in the manufacture of this type of fine paper.

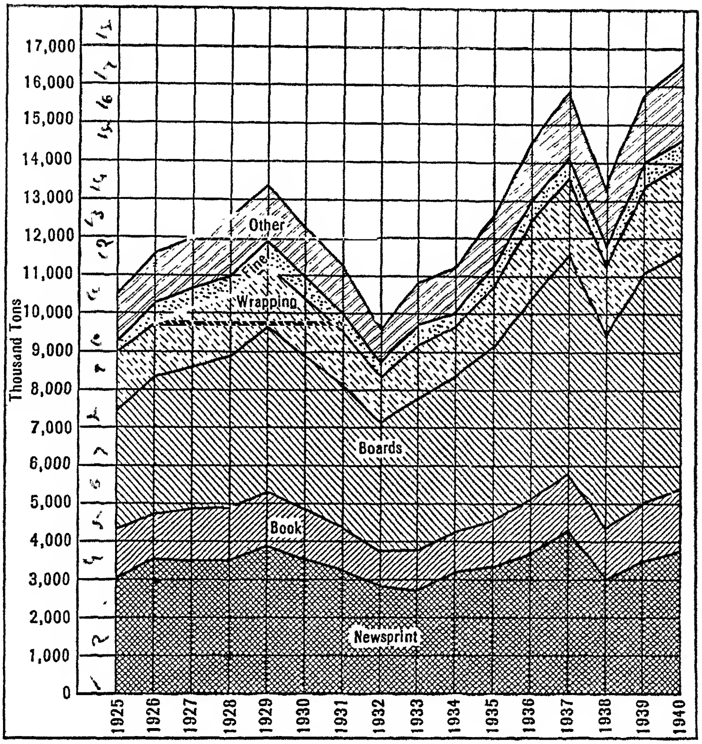
About four-fifths of all paper in the United States is made of chemical wood pulp,[34] the better and more expensive kinds being made of chemical wood pulp to which rag pulp is added to give a superior surface. High-grade writing and book papers are largely made of spruce and poplar (aspen) wood and

of the Arab tribes of North Africa. The resultant hard times produced discontent, which, as is commonly the case, was blamed upon the Government, and the French rulers of Algiers had serious trouble with the tribesmen who found themselves poverty-stricken through the loss that followed the decline in the esparto trade.

[32] In a country like England which imports its raw material and has many of its streams impure from sewage and factory refuse, the water supply is important in locating paper factories. For this reason British paper mills were chiefly located on the slopes of the central mountain range in Lancashire and Derbyshire, and in Scotland where the streams are clear.

[33] Sven A. Anderson, "Trends in the Pulp and Paper Industry," *Econ. Geog.*, vol. 18, April, 1942, p. 195.

[34] The sulfite process, employing a cooking solution of calcium bisulfide, is used to make pulp from such long-fibered and non-resinous woods as spruce, hemlock, and fir. Most wood pulp in this country is now made by the newer sulfate process, which can be used for both resinous and non-resinous woods. The sulfate process employs a mixture of caustic soda and sodium sulfide, the cooking takes more time, but much of the solution can be reclaimed and reused.



Amount paper consumption by kinds 1925 to 1940. The quantities show the great service of paper in both the intellectual and economic life of the age.

rags. Kraft paper, commonly used in the manufacture of tough lightweight brown wrapping paper, bags, and also paperboard, is made chiefly of yellow pine, this branch of the industry being dominated by the South. About one-fifth of the nation's paper is made of mechanical pulp, which is of inferior quality because the ligneous material is not removed and because the fibers are cut too short, this cheap "groundwood" pulp being used in the flimsy and perishable newspaper. In 1940 about three-fifths of our domestic newsprint was produced in the highlands of Maine and New York, most of the remainder being made in Washington and Wisconsin.

Development of Scientific Forestry. The manufacture of pulp and paper is a hog for electric power, and the large self-contained mill, producing both pulp and paper, usually manufactures its own power or is closely associated with a power company. A mill with its turbines and heavy machinery is expensive, and the great cost or impossibility of moving it makes it necessary that a paper company shall be sure of its wood supply. To do this they must often own the land, and, since they cannot flit from tract to tract after the manner of lumber manufacturers, some of the paper companies owning large areas of spruce land became the earliest large timber owners in the United States to protect

their forests and cut them rationally—forestry. As their enterprises are often located in the deep forest, the companies must sometimes even build and own the towns in which the people live who make their paper. A good example of this is afforded by the town of Millinocket, Maine, where a huge pulp and paper mill was located far in the forest beside a great waterfall. A special railroad was extended to it, and the town built around the mill. The original plant cost $25,000,000—an excellent evidence of the impossibility of moving and of the consequent necessity for conservation of wood supply, both by avoiding wasteful cutting and by replanting the burnt-over lands, but above all by stopping fires. This company now owns plants at Millinocket, East Millinocket, and Madison, with an aggregate capacity of 1,000 tons of pulp per day, and it owns or controls about 2,000,000 acres of forest land which is so well managed that it can yield pulpwood for an indefinite time.[35] The paper industry is undergoing rapid change in the source of its raw material. For a time the pulp supply was limited to spruce, then poplar and hemlock came into use, and now it has been demonstrated that a large number of native woods can be used. Already twenty species, including southern pine, hemlock and miscellaneous hardwoods are in use. Slabs and mill waste are also being utilized and there will soon be no excuse for the frightful wood waste of the past.[36]

Paper from Straw. Straw, of which great quantities are wasted in the United States, supplies about 4% of the raw material for the paper industry. Unfortunately, it will only make cheap wrapping paper and also the so-called pasteboard.

Our Huge Consumption of Paper. No other people in the world use so much paper as do the people of the United States with their large consumption of newspapers, magazines, books, wrapping paper, advertising materials and cartons. Between 1899 and 1940 our consumption of paper increased from 58 to about 250 pounds per capita. Although about 85% of all paper used in this country is manufactured here, we are dependent upon imported raw materials. During 1935-39 we imported about 2,200,000 tons of pulpwood a year, 2,000,000 tons of wood pulp, and 143,000 tons of rags and other paper stock. Virtually all of the pulpwood came from Canada; the wood pulp was obtained chiefly from Sweden, Canada, and Finland; while the rags were obtained from many European and other countries.

The newsprint paper supply of the United States presents a serious problem, as our demands for newsprint have more than doubled since 1915. Since 1925 our newsprint paper imports have exceeded domestic production, which has declined steadily since 1926, and in

[35] The great International Paper Co. owns stumpage rights of over 35,000 square miles of forest land. This goliath of the paper industry has 35 mills scattered from Ontario to Florida and from Newfoundland to Wisconsin. It supplies about one-fifth of the total newsprint demand of North America; about 26% of its capacity is devoted to making kraft and board paper, 9% to bags and bag paper, 6% to book and bond paper; and the company also produces one-half of the world's bleached pulp for rayon manufacture.—Evan B. Alderfer and Herman E. Michl, *op. cit.*, p. 261.

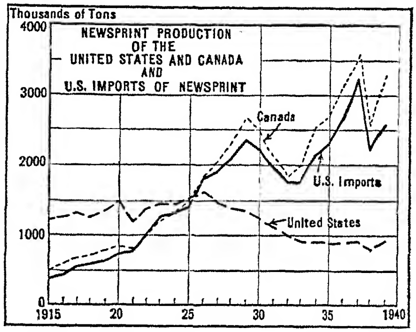
[36] The same company owning a pulp mill often operates a sawmill, and all the sawmill waste from spruce and fir is used in the pulp mill.

recent years the ratio of total imports to domestic production has been about 2½ to 1 (see Fig. 373). About four-fifths of Canada's annual output of 3,000,000 tons of newsprint paper is exported to the United States. More than 85% of our newsprint imports come from Canada, the remainder being obtained from Finland, Newfoundland, and Sweden. Many of the paper mills in New England, New York and Wisconsin are facing the early exhaustion of their forests. New pulp and newsprint mills are being built in the Pacific Northwest, and in time they may be built in Alaska. Perhaps the new Herty process for making newsprint pulp from the small and fast-growing pine trees of the South will enable us to achieve newsprint independence of Canada.

Newsprint is one of the few important manufactures that has always found a hole in that appalling structure, the United States tariff wall—a tribute to the power of the press. In 1944 Canada shipped to us 2,500,000 tons of newsprint paper, 1,100,000 tons of wood pulp, and 1,600,000 cords of pulpwood.

Paper Industry in Europe. Great Britain, one of the important paper-manufacturing countries, derives all of her wood pulp from foreign lands, principally from three Scandinavian countries. Most of the other European countries manufacture paper and many of them export it. Germany, located in the center of Europe where millions of people are daily converting clothing into rags, draws on the best raw material supply in the world for the manufacture of fine rag paper, and sends her paper products all over the world. Even Spain, which formerly shipped thousands of tons of bulky esparto grass to be made into paper in England and Germany and then bought the paper, is now manufacturing much of it at home.

In the production of wood pulp for paper the Scandinavian countries are in a position to supply the needs of all Europe and even ship large quantities



Newsprint production in the United States has decreased during the last 25 years while that of Canada has markedly increased. Virtually the entire Canadian output comes to the United States. Newsprint is one of the all too few products of which we can reap the advantages of free trade. The fact that every newspaper in the land uses newsprint and can raise a howl, and does so, loudly, has made it impossible for the paper manufacturers to get away with a protective tariff. Is there any other important exception? If so, please inform authors. (U. S. Dept. of Commerce.)

to the paper-hungry United States. Sweden, with her large percentage of forests for raw material and mountain streams for water power, exported pulp and paper valued at $120,000,000 in 1939. Norway with similar resources had an export of $40,000,000 and Finland's share was $67,000,000. (Compare these *per capita* with any element of American trade.) In all three countries wood in the form of paper and pulp was the leading export.

Paper in China and Japan. The Mongolians (save for the hornets) first invented paper and still make an excellent

quality and a large quantity of it. The cheap paper is made of rice straw, while the so-called fine "rice" paper of commerce the Chinese manufacture from the pith of a plant grown in Formosa. It is in Japan that we see paper rendering its greatest and most varied service. With a small arable area, the Japanese are compelled to make paper fill uses supplied in other countries by the products of agriculture. Thick, tough papers are substitutes for leathers, which they cannot produce at home owing to their lack of cattle. A very strong and durable paper is made from seaweed, and the Udo, a bush, also called paper mulberry, or paper plant, is grown on many Japanese hillsides for the very strong paper that can be made from its bark and used for grain sacks, for waterproof tarpaulins, and even for walls of houses. Paper is an excellent non-conductor of heat, and the native Japanese house, adjusted to the needs of a country that is often visited by earthquakes, is made earthquake proof by having a bamboo framework and paper walls. The Japanese paper umbrella and lantern are well known among us, and the Japanese have long used paper napkins and paper pocket handkerchiefs.

In Japan there are two separate and distinct paper industries: (1) the production of tough, pliable, native-style papers, including paper for brush writing and (2) the manufacture of foreign style paper.[37] The production of native-style paper, amounting to about 100,000 tons a year, is largely a household industry employing traditional handicraft methods introduced from China centuries ago. On the other hand, the manufacture of foreign-style paper, amounting to about 1,000,000 tons a year, is conducted in modern mills using machinery and methods imported from the United States and Europe,[38] and by far the greater part of the output is newsprint. The great bulk of all foreign-style paper is made of wood pulp, as only about 1,000 tons of high-grade paper are produced from rags and other fibers. As much as three-fourths of the Japanese wood pulp supply is obtained from the coniferous forests of Hokkaido and Karafuto (southern Sakhalin), the remainder being imported from the west coast of Canada and the United States. As in Scandinavia, Canada, and the United States, the modern production of pulp and paper in Japan is well endowed with water power.

The Future. Whatever may be said of the future of the paper industry, it is certain that forests and pulpwood supplies are dwindling while the demand for paper continues to increase. Fortunately, the pulp mill can use younger and smaller trees than the sawmill, but each year we are compelled to reach into more distant areas for both saw timber and pulpwood, and these are

[37] See Clayton D. Carus, *Japan: Its Resources and Industries*, Harper & Brothers, Publishers, New York, 1944, pp. 54, 211-212, and "Stuff of World Power," *Fortune*, vol. 14, September, 1936, p. 190.

[38] Some years ago a new $4,000,000 pulp paper mill was started at Tomakawai in the forested island of Hokkaido. It was the largest enterprise of the kind in the Orient, developing 15,000 horsepower from Lake Shikatsu 800 feet above, and its daily output of 70 tons supplied 50% of the consumption of the empire. All of the electric machinery and 97% of the paper machinery came from the United States, most of the paper machinery being made at Watertown, N. Y., in the midst of the Adirondack paper district. The Japanese method is shown in that one foreigner only was employed, an American to superintend the erection of the machinery. What Japan will do now remains to be seen. Karafuto wood is now foreign wood.

usually areas where it is cold and where trees grow slowly. Already the time and cost of producing newsprint pulp are being reduced by the Herty process which makes use of the young and fast-growing pine trees of our South. Perhaps the time required to produce pulp for paper and rayon will be reduced to a year, if scientists perfect the idea that cotton should be sown thickly in the field, forcing the largest possible number of bolls to mature at one time, harvesting the crop with mechanical pickers, and then recovering the cottonseed oil and the fibrous material with its high cellulose content.[39] Who knows but what the technology of the future may make it practical to use a much greater variety of cheap vegetable fibers in pulp and paper making? What we really need is a machine-grown, erosion-proof annual, such as one of the croatalarias. In the meantime, the need for scientific forest management is most urgent. For alarming details of this see "What's Happening to the Timber," *Harper's Magazine,* August, 1945. Trees planted *now* will sell in a *high market.*

[39] See National Resources Committee, *Technological Trends and National Policy,* Washington, June, 1937, p. 303.

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The Place and Nature of Agriculture

ɪʏ *The Antiquity and Basic Importance of Agriculture*

Primitive Agriculture. Perhaps it is a necessity of the human spirit that we must feel able to look down somewhat on other peoples if not indeed on other people. Certain it is that we do too much looking down on our fellows. Look at the case of the American Indian. Our literature and our school books bristle with the term "savage." If we could give it a psychological sifting and get to the bottom of this, we might discover that we were defending ourselves for having taken his land.

Look at his agriculture. Was he an agricultural savage? We took Oklahoma, his last block of good land, in 1890 and 1892. Many now living remember it well. Now look at Figure 377.

In less than half a century it had become one of the worst eroded parts of the United States, and thousands of farmers had abandoned their land and become homeless wanderers, "Okies," picking fruit from place to place in California. An Oklahoma Indian pointed out that his people had been there for centuries, but when we took the land the sod was unbroken, there were fish in the streams, and the land was as good as it ever had been.

Who is an agricultural savage? Is it the man who grows corn, cotton, and tobacco until the land is ruined in a few decades? Or is it the race that grows smaller crops for centuries, and still leaves the land as good as it ever was?

Our Soil Conservation Service reports that we of the United States, with our plows and other machines, have destroyed more land since 1900 than Japan has used to support 70 million people.

Let us look again at the "savage," and begin with the poor benighted African "savage."

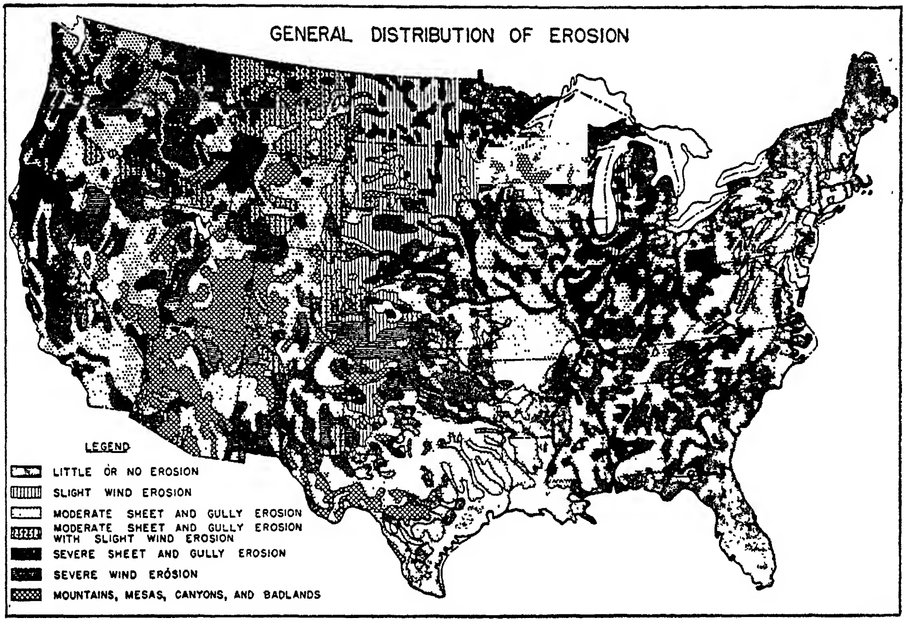
Now the fact is that the African forest peoples have been farmers for unknown centuries.[1] They are not farmers in the modern European or American sense, but they were and are practitioners of the primitive agriculture. A clearing is made, small trees are cut and burned and the larger trees deadened, and in this partial clearing bananas, cassava, upland rice or millet or sorghum, beans, tomatoes, pumpkins and other vegetables are grown. When this garden becomes full of weeds and undergrowth, another is cleared.

The native of the more humid grasslands of Africa has a similar garden. Only on the desert's edge were there

[1] For a discussion of the Fang, see Jean Brunhes, *Human Geography,* Rand, McNally, & Co., Chicago, 1920, pp. 453 ff.

For a discussion of the *conucero* and the easy method of living in the tropics, see J. Russell Smith and M. Ogden Phillips, *North America,* Harcourt, Brace & Co., New York, 1942, pp. 788-790.

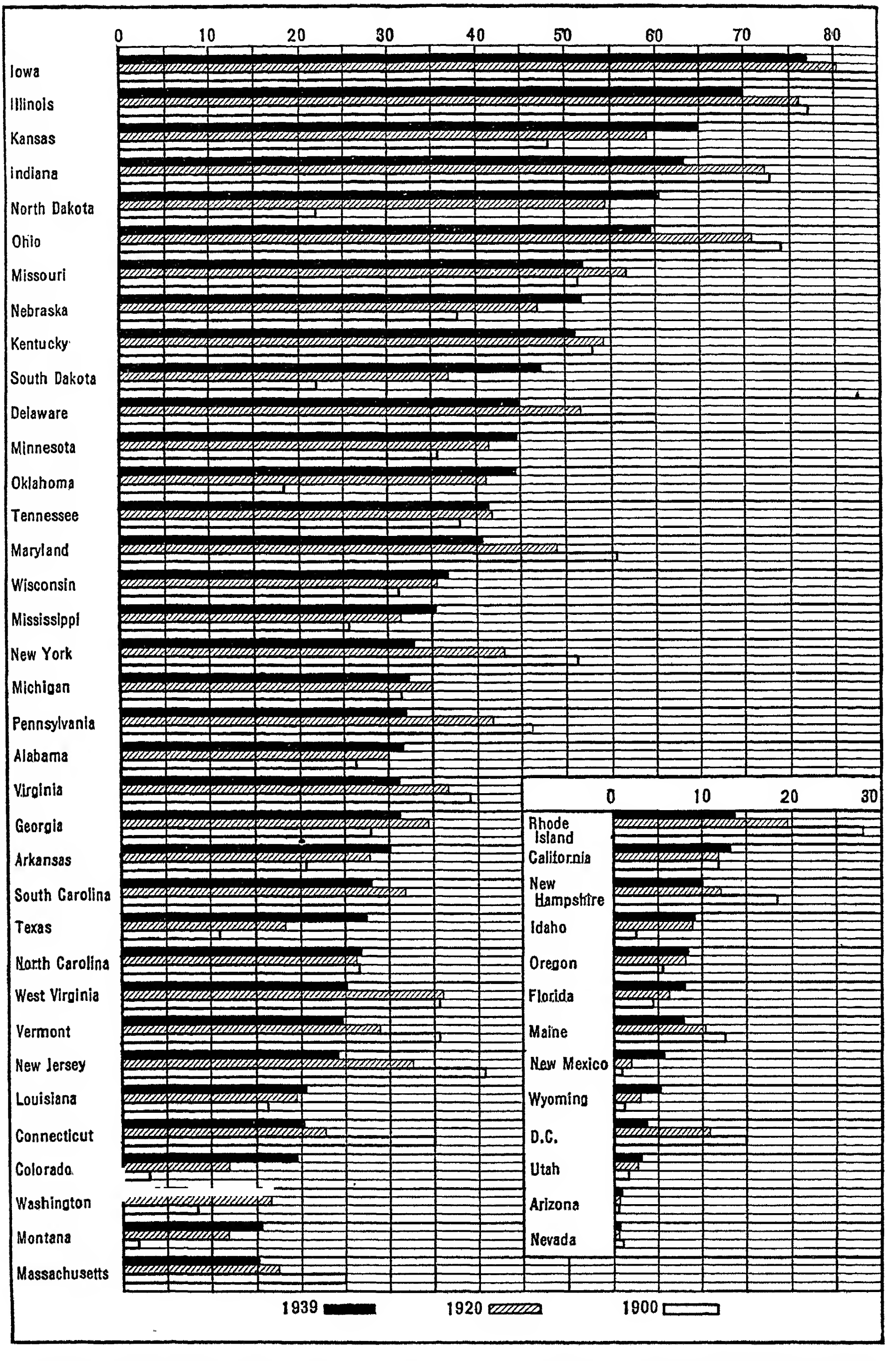
We need to differentiate between technology and civilization, also between profits and permanence.



Mene, mene, tekel, upharsin—the handwriting on the wall. A careful examination of this map should be terrifying to anyone who thinks of his country, his people, and the American civilization in terms of centuries. In the book, *Hay and History,* Vladimir Simkhovitch has made a good case, for soil exhaustion was the prime cause of the downfall of Rome, but Rome did not have the equipment to destroy soil as efficiently or as rapidly as we have and are doing.

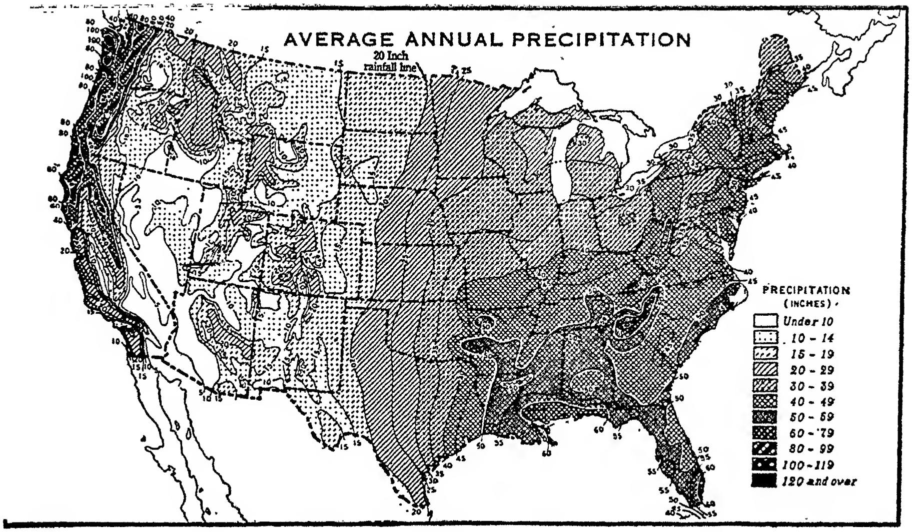
small numbers of true hunting peoples, living by wild produce. This is true throughout the world. No one knows when primitive agriculture started. It is age-old and world-wide. The American Indian practiced it in places where we do not farm. And it is an *enduring* agriculture. Ours often is not. Yet there was scarcely a breath of it in the American education of twenty years ago or even ten years ago. In many cases it has not yet entered American education. Indeed, few people have any conception of the importance of agriculture, past or present.

Importance of Agriculture in Modern Times. It is historically correct that agriculture comes first in any general study of the industries that arise from man's attempt to win support from his environment. Agriculture precedes manufactures in all nations. Among the moderns, it is the most fundamental group of industries. No nation has risen into importance in manufacture and commerce until after it had developed and lived by agriculture. It has not yet been proved that a people can long survive without an agriculture, despite the comforts of the world market. The world market is too uncertain. Agriculture furnishes raw material for the factory and food for the worker. 2Another important aspect of agriculture is its permanency if done well. The mine must be exhausted, the forest usually is, and the importing of raw materials from abroad is at best uncertain and at times



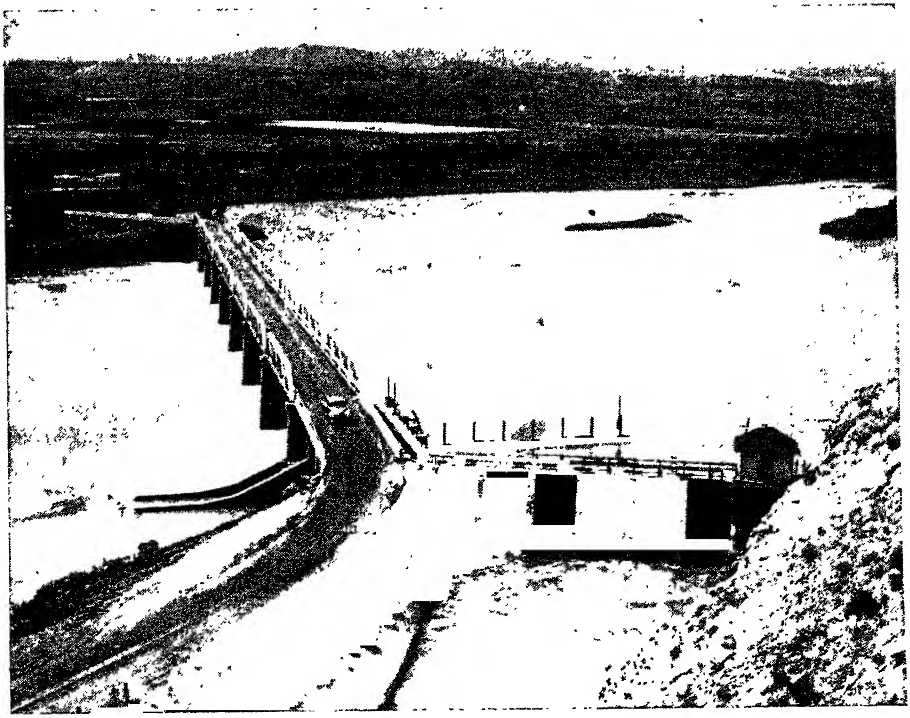
How big is the United States? This graph gives the economic answer. The wide open spaces are wonderful scenery. For many they feed the soul, but we eat food three times a day and it comes from agricultural land, chiefly, almost exclusively.

Examination of the changes in per cent of cultivation, both increases and decreases, are exceedingly suggestive. The United States has come of age. (Data from U. S. Conservation Comm.)



A

This map helps again to answer the question, "How big is the United States—the effective part?"



B

This dam and the irrigation canal, of which we see the head gates, is an attempt to overcome some of the limitations of the graph and the map, but irrigation involves the accumulation of an excess of something that is scarce in the place, and it can only serve a diminutive percentage of the land of little rain.

temporary. Thus, Great Britain some day may be unable to secure breadstuffs and meats from the United States because of our own increasing consumption and declining export, but especially because Britain may have naught with which to buy. In the long run the only sure dependence of a nation is its soil resource, upon which depends agriculture, the fundamental group of industries, and the soundest basis of national strength. During 1929-34, years of acute business depression, the soil looked good to 2,000,000 Americans who returned to the farms and to 2,000,000 youths remaining on the farms who would have migrated to the cities if factory jobs had been available.[2]

In the study of economic geography one must look closely at the factors that make for the support of human life—the fitness of land to man. Fortunately this fitness of lands to support us is rapidly increasing in spite of the present destruction—often reckless and useless destruction—of resources. Our inventions, discoveries and new abilities to do new things in both manufacture and agriculture enable us to create new products and get our living more easily, so that the various kinds of lands that make up our world will support more people than at any previous time. In recent years 19 people on farms in the United States have been producing enough food for 56 people not living on farms and for 10 persons living abroad, whereas in 1787 the surplus food produced by 19 American farmers went to feed only 1 city person.[3] These figures need to be considered in the light of the tallow candle and the spinning wheel and the rest of the elements of the domestic epoch.

2. *Relation of Transportation and the World Market to Agriculture*

The Development of Fertile Interior Plains. Since the rise of the world market and world commerce, in the Machine Age, one important product will support more people in greater comfort today than could have been done in a locality with several products in the older periods. Before the coming of railroads, level treeless plains in the continental interiors were almost useless to man, and he clung to the waterway with trees along its banks no matter how fertile and productive the treeless plains were. The first settlers of Illinois shunned the rich level treeless prairies and fought stumps and hills on the forested areas near the streams. The problems of shelter and fuel were perplexing without trees or coal. About the only way this difficulty could be met was to follow the methods practiced by the people of northern China, who have succeeded in living in the old-fashioned way on such plains by building mud or unburned brick houses covered with thatch, and using, for fuel, the coarse stalks of a kind of millet which they grow as an annual crop for this purpose. Owing to the scarcity of this fuel supply they must economize severely, and therefore make no attempt to heat their rooms. They wear quilted cotton or

[2] National Resources Committee, *Technological Trends and National Policy*, Washington, June, 1937, p. 100. Among the millions of Americans futilely seeking jobs during the depression years of the 1930's were tens of thousands of farm families fleeing from drought, dust storms, grasshoppers, and eroded land—unscientific agriculture.

[3] *Ibid.*, p. 99.

thick sheepskin clothing instead, and sit by day and sleep by night upon a low, hollow brick platform continually kept warm by a small fire of millet stalks smoldering beneath it.

Significance of Easier Access to Market. World commerce enables western peoples to live very differently on such plains. The vast treeless plains from Texas to Manitoba and westward to the Rocky Mountains have become the home of millions of comfortable farmers and townsmen, who bring their wood and their coal hundreds of miles and pay for it with their wheat and corn and cattle, their sheep, and their hay, while they ride in automobiles and many live in houses supplied with bathrooms and electric lights.

This fact, that a community can arise wherever one salable product can be produced, has multiplied the world, and makes it necessary to examine a region very closely to see its possibilities.

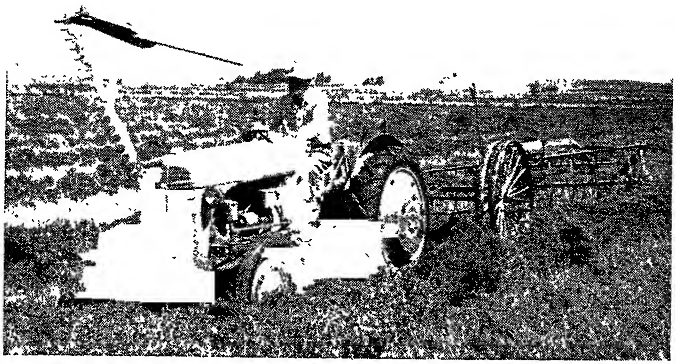
Because of the fundamental character and enduring nature of agriculture, if soil be preserved, one of the first things to note in the examination of any region is its fitness for this group of industries.

3. Contrast Between Farming in the Domestic and Commercial Epochs

Self-sufficiency of the Farmer in the Domestic Epoch. Farming, like manufacture, has been revolutionized by world commerce. In 1787 a Massachusetts farmer wrote a paper telling just how he supported his family.[4] With the wheat and corn and buckwheat that grew in his fields he furnished the family bread. The chickens, pigs, sheep, and an occasional beef animal that he slaughtered furnished the meat. His garden furnished all the vegetables and his orchard all the fruits, many of which were dried for winter use. The farm produced the family food. For clothing, his wife spun the wool which he sheared from the sheep; and the flax that grew in the corner of a field was made into linen. The skin of the meat animals was tanned and made the family's shoes, and thus were they clothed. The trees from his wood lot furnished the boards to build his house and the logs for his fire and the rails for such fences as were not of stone. He himself, as most farmers of that time, was a fairly good worker in wood, and he had a little blacksmith's shop so that he made practically all of his own tools on rainy days and in snowy winter weather. Only a few things were needed from the outside world, such as salt, pepper, crockery and iron for his little forge. These outside products cost him $10 a year, permitting him to save $150 out of the $160 received for the wheat and cattle that he sold. This glorified primitive agriculture, this completeness of support was obtained by an amount of hard work and discomfort that would not be tolerated in this age of commerce and division of labor—hence the abandoned farms of New England.

Farming in the Commercial Epoch. Since the coming of the epoch of coal, steam, and machinery, the farmer, especially the American farmer, sells much more and buys much more, and his family usually does less work. His shoes

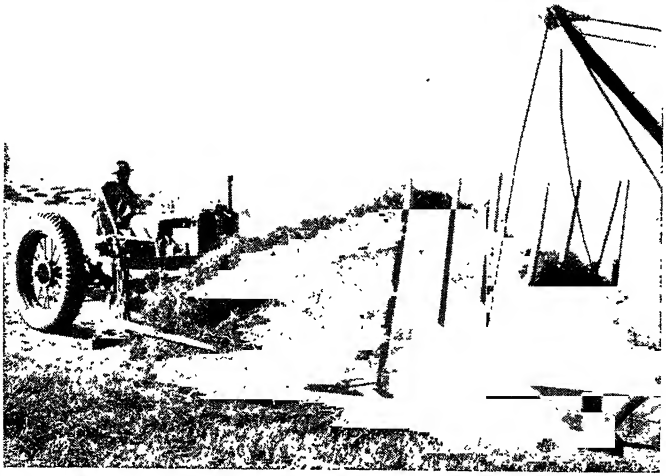
[4] See John B. McMaster, *A History of the People of the United States from the Revolution to the Civil War*, vol. 1, D. Appleton & Co., New York, 1883, footnote, p. 19.



A

Maud Muller on a summer's day
Raked the meadow sweet with hay—

and according to the poet, Whittier, she made considerable hay, metaphorically. From the cows' standpoint, she did not make much hay, for she worked in the day of the scythe and hand rake. The three pictures visible here show the mechanization of the hay industry. See the long cutter bar attached to the tractor, which cuts as much as 15 or 20 men could do with scythes. Then the tractor puts the cutter bar up into the air and pulls the hay rake—modern type, side delivery, which rolls the hay upside down into a windrow to dry the bottom of it.



B

The tractor pushing the long fingers of wood ("bull rake") ahead of it, picks up the hay from the windrow left by the side delivery rake and carries it along until it deposits it on the hay sling. See next picture.

and clothes are factory-made, the lumber for his new barn often comes from afar, as does the coal for his stove and the stove itself, as well as the tools, the wagon, and often the horse that draws the wagon as well as the gasoline that runs various engines. A much greater farm product is required to support a family by the commercial than the domestic system. The increased product goes to pay for things not done on the farm. To see this clearly take the matter of clothing. A flock of fifteen sheep yielding 75 pounds of fleece would abundantly clothe a family with homespun. If the same 75 pounds of unwashed wool were sold at forty cents a pound, the resulting $30.00 would scarcely buy one-tenth as much ready-made woolen clothing.

Thousands of American farms that successfully supported large families in the domestic epoch will not do so in the commercial epoch, and hence have been abandoned. These farms are to be found in every state. In the nineteen-thirties the United States Government discontinued the sale of public land and began to purchase submarginal land that would no longer yield a living. Indeed, there are a million farms in this country today that should be abandoned, according to Washington recommendation. It is poor land and injured land that is wasting human lives. In the commercial system, the most important consideration in connection with farming is the money crop. Every farm or every farming community has one or more crops which are usually sold and converted into cash, and hence usually called money crops. Among the world's great money crops are grain, sugar, animals, fruits, and vegetables, cotton, wool, coffee, tea, and tobacco. The money crops do not occupy half the land in American farms, for most of the land is devoted to what may be called supply crops, that is, crops which are used entirely upon the farm and are sold, if at all, in some indirect

The horse in the distance pulls the rope, the hay sling rises up and throws the hay it has received from the bull rake far back on the rick where the man waits to place it.

form. For example, nearly half of the American farm lands are in grass. Some of it the animals eat in summer, the rest is made into hay for winter forage, so that, while important, the pasture and hay are not sold directly, but supply the means for producing something else. On many farms there may be fields of corn, oats, hay, grass, and rye, yet these are often supply crops contributing to the one money crop of milk, butter, sheep, cattle, swine, or horses. Market price is the eternal question.

The Farmer and the City Man. The complete self-support and the well-nigh

money-free life of which the Massachusetts farmer wrote 160 years ago are gone, but many of the advantages of the old domestic epoch remain. Nearly every farm has a garden, from which, more or less, a complete supply of vegetables is drawn to last the family through winter and spring as well as for summer use. It also has an orchard in which some fruit may be grown, so that no fruit need be bought, for the home supply can be stored, canned, preserved, or dried for winter use. One or two cows furnish milk and butter. A few chickens about the farmyard supply the farm with eggs and poultry, and usually leave some to sell for cash. Millions of farmers raise a few hogs or sheep or cattle which they slaughter for their own meat supply. Even the dwelling house, usually considered part of the value of the farm, is used rent-free by every rural family.[5]

In contrast to all these benefits of the farm, which are had without direct cash cost, the entire food supplies of the city consumer must be bought, and at prices that are often several times higher than they were in the country, because of the great amount of work and expense necessary to get the products from the place where they are grown to the consumer's house. When the city housekeeper, for example, buys a basket of beans, she pays for the beans and in addition pays for the following: one basket, the cost of packing the basket ready for shipping, cost of hauling it to the station, transportation charges from the farmer's station to the city, cartage from the railroad station to the commission house, commission to the merchant for selling it, cartage from the commission house to the grocery store, and profit to the groceryman. This profit to the grocer must be based on all the costs that have accrued before the goods came to him. This profit must also be large enough to include rent, clerk hire, delivery costs, and the value of the damaged goods that cannot be sold. All these costs and charges reach a total that amounts to about sixty-five cents out of every dollar expended by the housekeeper in a great American city for farm products. Only the remaining thirty-five cents of the dollar get back to the farmer, with the result that living in the city is much more expensive than living in the country—a frightful waste of effort and resource for an object that might often be otherwise obtained.

In many small towns and country districts of the United States, a family can live with as great comfort and independence on $1,000 per year as one can live in a great city for $2,000; or, again, in the same rural regions referred to, $1,500 a year would make one relatively wealthy, while $3,000 per year in a large city leaves one relatively poor. These statements are made with reference to the real country and not the suburbs, in which the cost of living is often higher than in the great cities, because it involves one more movement of supplies—from the city center to the suburban town. Cities have grown up so

[5] The farmer's cost of living in actual cash expenditures is very materially reduced by what the farm furnishes in food products, fuel, and house rent; in fact, such benefits add as much to the real wealth of many farmers as does the net income from the sale of farm products. But don't conclude that these benefits are without cost, as the farmer must work long hours for all that he gets!

suddenly that these differences between city and country conditions have not been fully appreciated. Now, however, there is coming a rapid increase of understanding of the conditions of living in the country, where one pays for the things he gets, as contrasted with the great city, where he must pay, also, for a host of services that add no value to the goods and often detract from their value.

4. *The Application of Science to Agriculture*

The Need and Increase of Agricultural Education. Farming is one of the most scientific branches of production. A factory has a few operations involving a science or two, but the farmer must deal with soil chemistry, plant nutrition, animal nutrition, and the diseases and enemies of both plants and animals. He must also be his own purchaser, salesman, and to some extent mechanic. Much experiment is required in all this wide field, but in no occupation is experiment so difficult. Experiment consists in altering *one* factor, the others remaining as before. The vagaries of temperature, humidity, rainfall, sunshine, and accident make experiment difficult. Hence superstition has lingered longest in the most scientific of industries. When one succeeds with experiments it often takes years, and then the cycle of production is so slow that there may not be much of his life left in which to profit by the experiments. In a factory an experiment may easily affect more cycles of production in a year than farm experiments will in a lifetime. Further than this, many experiments of great value to agriculture are too difficult and costly for farmers to perform, but, at the same time, they may be of great profit to a community or state. Hence agricultural experiment has been largely taken up by the state, a great boon to the farmers.

Nearly all progressive governments are working systematically to promote agricultural production. In the United States we have in every state a college of agriculture and the mechanic arts, with practically free tuition. Every state has one or more agricultural experiment stations where men are supposed to be constantly making scientific discoveries and testing the usefulness of other discoveries for their particular localities. These results are published and distributed free, so that the individual farmer may be able to use the latest results of science. In addition, we have at Washington, under the national government, the Department of Agriculture, which is one of the greatest scientific institutions in the world. Let us hope that it can escape the withering clutch of conservatism, an endemic disease menacing all institutions as the years advance. Along with many other lines of work, it sends its explorers into the Desert of Sahara, into subarctic Russia, into tropic Africa, into Turkestan, Mongolia, and the ends of the earth where perchance may be found some plant, or practice, of value to some part of the United States. This plant introduction work has achieved great results and promises to increase the productivity of the United States more than would the addition of a new state.

Germany, with 87 experiment stations in 1904, formerly led the world in

the promotion of scientific agriculture.[6] Great Britain, France, Holland, Belgium, and all progressive countries of Europe are also in the same work. Uruguay, Argentina, Canada, and Australia are going at it in earnest. Cyprus (British) is well equipped, while Japan recently was, in some respects, more advanced than any other nation. This worldwide distribution of scientific research for agriculture gives to Massachusetts or California the possibility of hearing at once of discoveries that may be made in foreign lands. The result is that it is now becoming possible for agriculture to be actually one of the most scientific of all industries, since the experiment station and the Department of Agriculture bring experimental science within the farmer's reach. As a result, agriculture is becoming more and more an occupation for the educated man. A recent phase of the promotion of agriculture in America has been the use of county agents. These men are teachers with a county for their field and with any who will listen for their school.[7]

The greatest work for the promotion of agriculture now is the popularizing of science;[8] involving the practice of what is now known so that we may have an agriculture that is adjusted to resources. This adjustment is a very complex thing; for the crop selection is influenced by character of soil, land values, labor supplies, transport facilities, market conditions, climatic conditions, and the likes, dislikes and abilities of men.

Crop Rotation and the Intensification of Agriculture. The start of commercial agriculture is almost always the one-crop system—the planting of one profitable, easily grown money crop year after year, until its yield becomes low and unprofitable. This practice is limited to no one crop, climate, race, or continent. Then variation of crops follows (usually with the increase of population and workers) and, if this variation is systematic, it is called rotation of crops. This rotation causes variation in the demands upon the soil and gives it time to recuperate from the strain of any one crop. If sufficient humus is provided, by the plowing in of plant roots, leaves, manure, etc., and the soil is not allowed to wash away, agriculture may, with crop rotation, continue on the same fields for indefinite periods, as in parts of Europe and Asia. The violation

[6] The pressure of population upon available resources in the form of high land values and high rents compels the German farmer to adopt scientific practices resulting in high yields per acre, as the following contrast indicates:

BUSHELS PER ACRE (1930–34 AVERAGE)

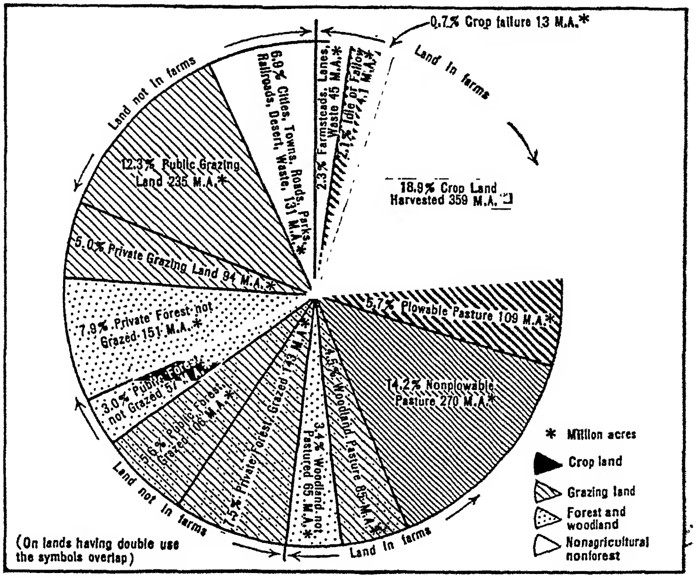
	Wheat	*Rye*	*Barley*	*Oats*	*Potatoes*
Germany...	32.1	27.6	37.0	53.5	237.9
United States....	13.5	10.7	20.1	26.2	108.0

[7] The county agent has resulted partly from the innate conservatism of the farmer and partly from the inability of bulletin writers to reach him with their message. Read a few of the bulletins and you will see why.

[8] As an example of results of such endeavor, note the following astonishing increases in average yield resulting from twenty-five years of teaching in Belgium:

BUSHELS PER ACRE

	1880–85	*1907–10*	*Increases*
Wheat..........	24.54	38.55	14.01
Rye............	23.86	36.69	12.73
Oats...........	49.79	81.48	31.69
Winter barley....	38.25	57.57	19.32

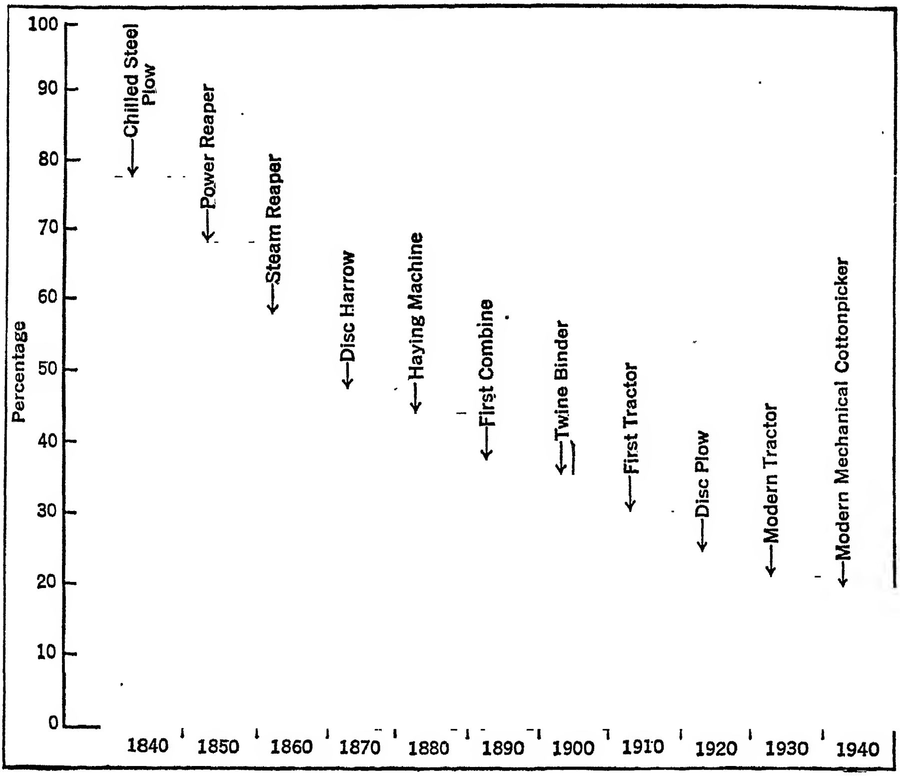


This graph gives the statistical measure of the land shortages shown by state percentages, Fig. 378. You may be surprised at the small proportion of crop land.

of these simple rules of soil preservation has in a few decades already brought irreparable ruin to many American fields, especially in the southeastern states. The keeping of live stock is the type of agriculture which best preserves the soil, because it permits the return of the manure to the land and thus tends to maintain fertility.

The Decline in Farm Population and the Increase in Productivity. During the past century there has been throughout the western world a steady decline in the proportion of the people engaged in agriculture, and in many areas, as in our Corn Belt, there has occurred a decline in the farm population although the output has continued to increase. A startling increase in the use of labor-saving machinery and more scientific methods of farming have made it possible for fewer farm workers, with less human toil, to produce more than ever before. In the spring of 1945 there came a news release from official sources to the effect that there were 5 million fewer people on farms in the United States than in 1940 and the farm product had increased 35 per cent. Small chance for the returning soldier who wanted to farm. (See section on farm machinery in this book.) Another factor tending to reduce the proportion of farmers is the carrying over to the factory of so many operations that were once done on the farm.

In 1840 77.5% of the gainfully employed population was engaged in agriculture; in 1870, 53%; in 1910, 31%; and in 1940, only 18.5% (see Fig. 53). While the proportion of people engaged in farming has steadily declined, the long-run trends in crop acreage and in crop output for decades has been upward, but these trends no longer zoom upward like a rocket. Although crop



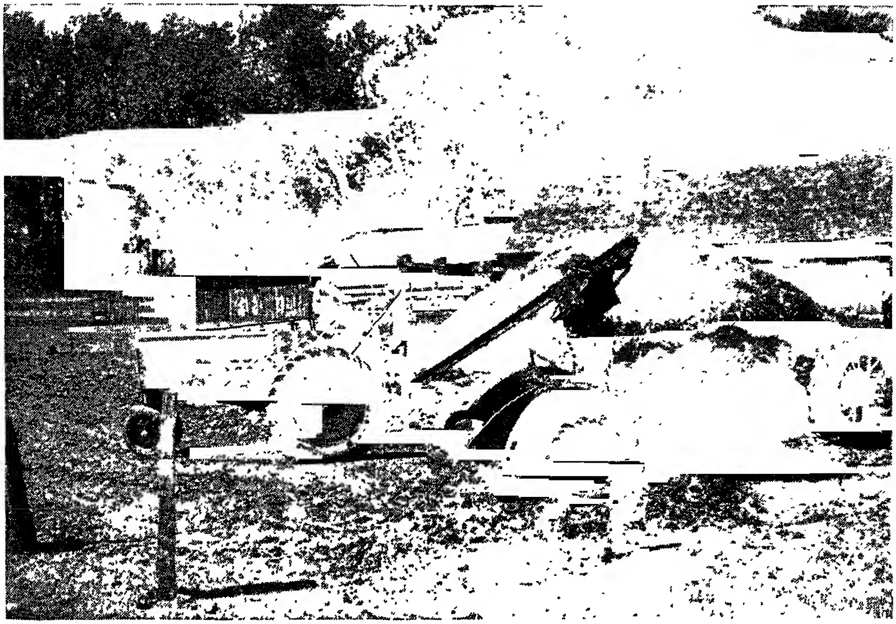
Percentage of farm workers in relation to the development of labor-saving farm machinery. Note that each new machine reduces the number of farm laborers even as it increases the total output.

production per capita has declined since 1891, and especially since 1920, the production per farm worker has steadily increased.

Diminishing returns that accompany the increase of population are a factor tending to increase the proportion of agriculturists. Crop rotation, the intensification of agriculture, can increase the output per acre, but rarely the output per man. When four families support themselves respectively on a 2,000-acre ranch, as in the American West, or on a 160-acre farm, as in the Corn Belt, or on a 20-acre farm, as in France, or on a 2-acre garden farm, as in Japan, there is no questioning the fact that a Japanese *acre* is the most productive acre and the American *family* the most productive family. During the last half century the discovery of new lands and the increase of machinery have been influences that have, for a time, much more than offset the more fundamental influence of diminishing returns from increase of population.

5. *Agriculture in the Machine Age*

Results of Mechanization. This is the Machine Age. More and more it becomes the Machine Age. The students of economic history say that the Me-

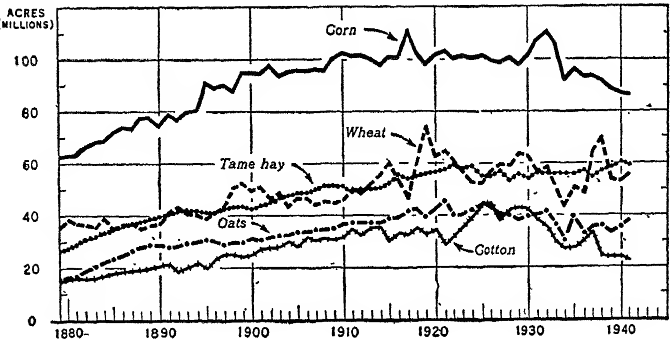


The last word in farm machinery. The tractor, modified by some steam shovel technique, cleans out the stable or the barnyard by taking up loads of manure and dropping them on the manure spreader, thus completing the application of machinery to all the main agricultural processes as applied to staple crops: plowing, fitting the soil for seed, seeding, cultivating, harvesting, threshing—and here the refuse is picked up and put upon the manure spreader to be hauled back to the field ready to start another crop cycle.

chanical Revolution, or the Industrial Revolution as it is often called, meaning the change from muscle-driven to power-driven machinery, began in the last half of the eighteenth century. But actually the development and extension of machinery, the increase of its power, efficiency, and use have been taking place more rapidly in the years that have followed World War I than in any other period in history. In 1850 the average farm worker in the United States had 1½ horsepower at his disposal. In 1900 he had 2½ horsepower, 2 of which were animal power, and ½ was mechanical power. In 1930 the farm worker had 5½ horsepower at his disposal, but only 1½ was the power of live horses and mules, the other 4 being produced by machines (see Fig. 394.)

The new machinery has altered both manufacturing and agriculture. New knowledge of farm crops, of fertilizers, and of plant and animal breeding has also increased the possibility of agricultural production. The result has been changes revolutionary in character, and the farmer finds himself with an entirely new outlook upon the economic world.

In the old era of domestic agriculture, good harvests meant prosperity. The farmer had the *goods* he needed. In the new commercial agriculture, prosperity depends upon good *prices* and something of a crop, so that the farmer may



Crop acreages in the United States, 1880 to 1940, indicate that the United States has for the time at least ceased to grow agriculturally. The most potent factor of the acreage decline is 50 million acres no longer needed to grow horse feed. Cotton is down by government restriction, hay for the milk and beef supply stays up.

get the *money* he needs. An extra large crop is coming more and more to be a calamity to the producer and no particular advantage to the consumer.

The statistics [9] on almost any American farm crop, such as corn, potatoes, or cotton, will show that the farmers as a whole receive greater income from a small crop than from a large one. In 1926 about 2 or 3 million bales of cotton went unpicked in this country, and the rest sold at the price of picking. In the same year some 20 or 30 million bushels of apples went unpicked, while 120 million bushels sold at the cost of picking or less.[10] There is a glut of truck crops in some of our city markets almost every month of the year. Continuous surpluses are sure to bring ruin to thousands of producers. Hence one of the great objectives of American producers is the maintenance of relative scarcity.

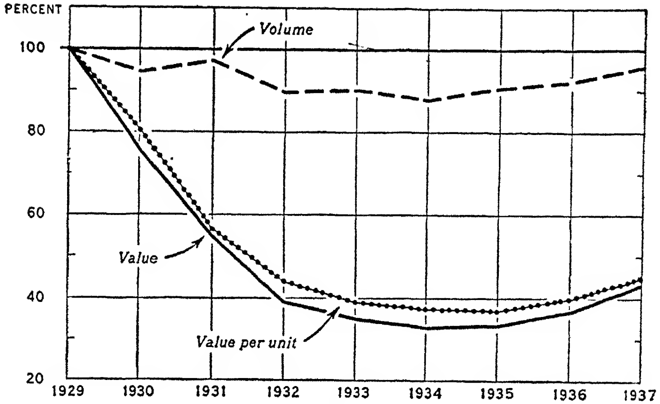
In the interim between World War I and World War II American agriculture was generally unprosperous and depressed at a time when producing capacities for both food and factory stuff were greater than ever before. O. E. Baker, of the Bureau of Agricultural Economics, states it thus. "Farm production in the United States for the five years ending in 1926 was 14% greater than the five years ending in 1921. During this time the total population, therefore the demand for farm produce, increased but 9%." And to make it worse our exports declined and there was national and international clamor to check farm production—the fear of abundance. Between 1920 and 1940 the value of farm land in the United States declined from 54.8 to 23.2 billion dollars.[11]

Throughout this period the prices received by the farmer for his products were low in comparison with the prices that he had to pay for the commodities which he bought. In 1920-24 the ratio

9 See U. S. Dept. of Agriculture, *Agricultural Statistics*, published annually.

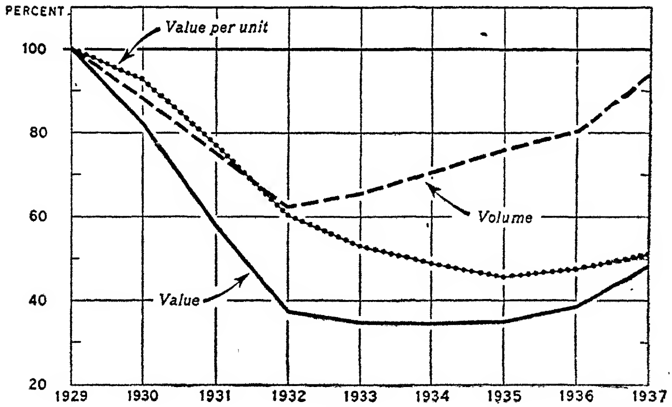
10 J. Russell Smith, "Agriculture: General Problems," *Encyclopaedia of the Social Sciences*, vol. 1, The Macmillan Co., New York, 1930, p. 597.

11 During this period the value of livestock declined from 8.0 to 4.6 billion dollars; farm buildings declined from 11.5 to 10.4 billions; and farm implements and machinery, from 3.6 to 3.1 billions.—U. S. Dept. of Commerce, *Statistical Abstract of the United States, 1942*, Washington, 1943, p. 694.



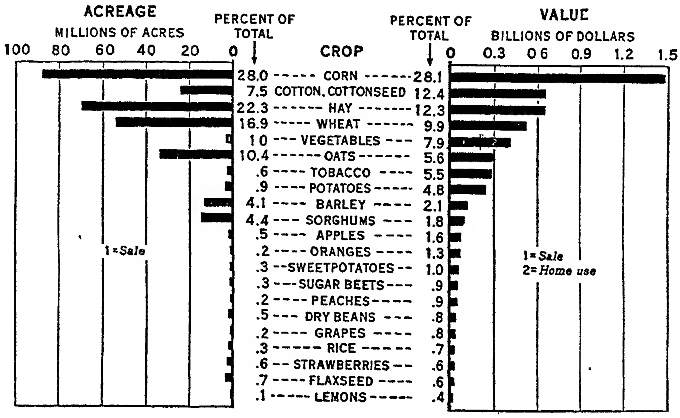
A

Volume and gold value of world exports of agricultural products, 1929 to 1937. Index 1929—100%. Note the very small shrinkage in the volume, but the tremendous shrinkage in price (value per unit). The United States government can prop up a lot of domestic prices by varied devices, but exports are another matter.



B

Volume and gold value of world exports of non-agricultural products, 1929-1937. Index 1929—100%. In comparison to the graph of agricultural products, this shows that the price of the non-agricultural products did not go down so much, but the volume went down much more.



Principal crops, United States, 1939, relative importance in acreage and farm value. The comparison of ratio between acreage and value is an interesting measure of agricultural intensity of the particular crop. A similar graph for Japan or Egypt would look very different.

of prices received to prices paid was 93%, in 1925-29 it was 95%, during the hard years of 1930-34 it dropped to 71%, in 1935-39 it was 85%, and in 1941 it had risen to 93%.[12] These are the kind of facts that cause people to migrate from farm to city. Between 1920 and 1940 the number of people on farms decreased from 31,600,000 to 30,500,000, and this decline undoubtedly would have been greater had it not been for the generous outpouring of funds from the federal treasury into the hands of the farmers during the depression years of the nineteen-thirties.

The Curse of the Glutted Market. While agriculture boomed during World War I and again during World War II, the intervening era of peace was indeed a difficult period for the farmer, because the markets for farm products were so easily glutted and because the purchasing power of the farmer's dollar was seriously reduced by the discrepancy between the prices received by the farmer and the prices which he had to pay. Each year the farmer has certain costs to meet: taxes, interest, wages, seed, fertilizer, equipment, fuel for his machinery, and other expenses of farming. These must be paid when due and *in cash*. When the price of goods and services that he buys goes up without a corresponding increase in the price of crops, the farmer's only recourse is to produce more crops in an attempt to increase his cash income. This, in turn, tends to glut the market and to depress the price of farm products. Thus, the farmer, a helpless victim of the fickle forces of supply and demand, is often forced to dig his own financial grave deeper and deeper. Among the developments of recent years that have helped to glut the market for farm products, the following may be noted.

1. We eat less than we did 30 years ago. In the factory man has become a machine tender. It takes less calories of energy, less food to push a lever than to lift a load; to ride a tractor than to

[12] U. S. Dept. of Commerce, *op. cit.*, p. 743.

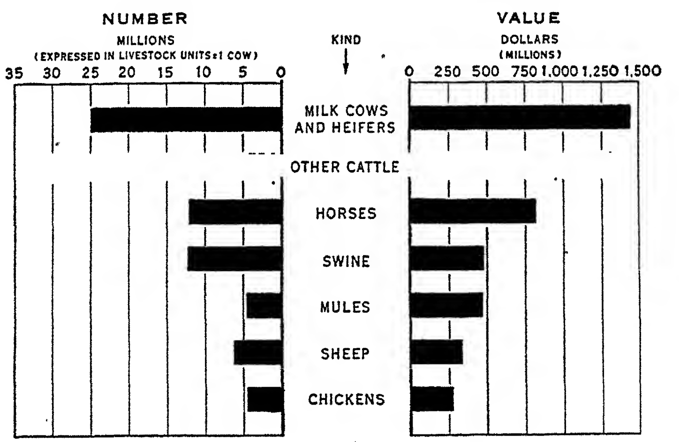
follow a plow; to pull the lever of the steam shovel than to lift the dirt with your own muscles; to step on the gas than to walk all day. Furthermore, to make things worse for the farmer, the American diet in this age of vitamins is shifting rapidly from a meat basis to one of cereal, fruit, and leaf greens, all of which require less land for production than meat.

2. We also need less land than we did a few years ago, because the truck and tractor have displaced millions of horses and mules which no longer exist. It is estimated that the loss of about 9,000,000 horses and mules on American farms between 1918 and 1932 released more than 30,000,000 acres of crop land and pasture for other crops.

3. The knowledge of applied heredity is becoming widespread and applied by organized effort. Within a single decade the average American cow increased her milk output by a thousand pounds, or *about 25%; but she has only increased her own food consumption 15%*.

4. Knowledge of breeding and feeding beef cattle has reduced their number and increased the amount of beef, because these animals used to be from three to five years old when they went to the slaughterhouse. Now they go in from a year and a half to three years. Similarly the hog goes to market at an earlier age and therefore spends less energy from corn in keeping his big body alive, keeping it warm, and moving it around. A similar increase in the use of lamb rather than mutton has shortened the average life of the sheep, resulting in an increase of meat without any increase in the number of sheep. Thus, science has enabled the farmer to produce more beef with fewer cattle, more lamb and mutton with fewer sheep, more pork with fewer hogs, and more milk, butter, and cheese with fewer dairy cows.

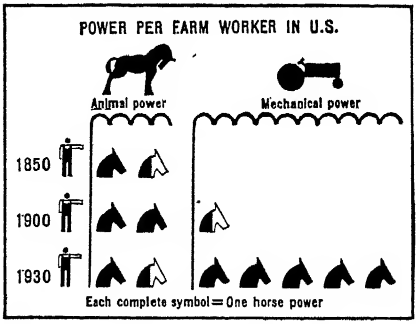
5. There has been some slight increase in the yield per acre of American crops and a marked increase in the cultivated acres per man. This is especially true in the grain crops like wheat, oats,



Farm animals—number and value—United States, April 1, 1940. Note that this has been reduced to a unit which is the equivalent of one cow. This graph shows a high ratio of land to men.

barley, rye, which grow without cultivation in the rows. The tractor and the combine (harvester and thresher) have aided in the increase of acreage which one man can tend, and improvements in these lines are apparently being made more rapidly now than ever.

6. The European market for agricultural imports is not so good as it once was, for here the products of the American farm are faced with keen competition from the products of the newer lands of Canada, Argentina, and Australia where mechanized methods are used just as effectively as in the United States. Furthermore, many European farmers long ago learned the lessons of scientific agriculture, and he, too, has adopted the new machinery whenever practicable.



Why do we have such a large proportion of our people living in cities rather than on the land growing food? This graph gives part of the answer and it explains the positive decline decade after decade of the farm population on the best farm land in America—also the increasing size of farm on land of this type.

Thus the food markets of the United States have been glutted with a slight decline in the area of crops, a decline in the number of live stock, and a decline in the number of people engaged in agriculture. The problem has passed out of the hand of the individual into the field of relationships between large social (economic) groups.

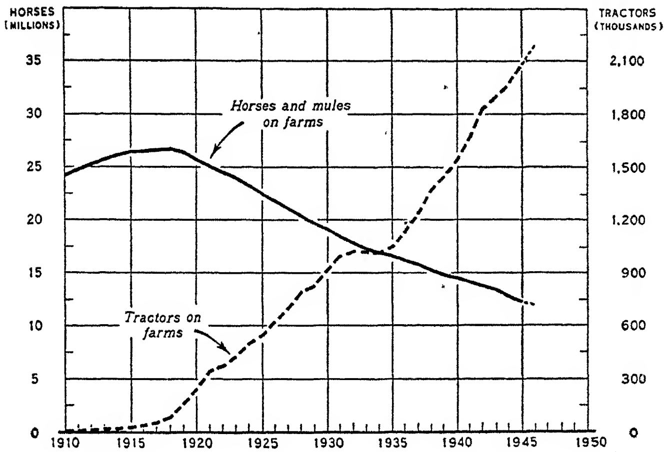
Despite the example of Denmark, a nation governed by farmers, the farmer in the United States seems to be peculiarly helpless in competition with the other classes of the industrial society of the Machine Age.

The Comparative Position of the Farmer. Compare him with the manufacturer.[13] Most manufacturers in the United States deal with a definite market *on order*. If they do not have orders, they do not make. Therefore, they shut down and do not glut their market. The farmer does not produce on order. He must produce for a *future market*, and he cannot know what the supply or demand or price will be. And even if the farmer knew the prospects, it is much easier to shut down a machine than it is to shut down a cow or an orange tree.[14]

The manufacturer deals with a short cycle. He manufactures today for delivery next week or next month. He can quickly meet conditions. If a man

[13] *Cf. supra,* p. 23; J. Russell Smith, *op. cit.,* pp. 597-598, and Erich W. Zimmermann, *World Resources and Industries,* Harper & Brothers, Publishers, New York, 1933, pp. 157-177.

[14] From 1929 to the spring of 1933, the *output* of farm products in the United States declined only 6%, while the *prices* of these products dropped 63%. In the same period, the *output* of farm implements dropped 80%, of motor vehicles 80%, of cement 65%, of iron and steel 83%, and of automobile tires 70%. However, the *prices* of farm implements in this period declined only 6%, of automobiles 16%, of cement 18%, of iron and steel 20%, and of automobile tires 33%. Thus, the purchasing power of the farmer's dollar was greatly reduced during the worst of the depression. The farmer must continue to produce in hard times, while the manufacturer can save money by curtailing production or by shutting down his factory.—See U. S. Dept. of Agriculture, *Yearbook of Agriculture, 1935,* Washington, 1935 p. 5.



Up goes the iron horse, down goes bone and muscle. Do not overlook the actual numbers. See margins.

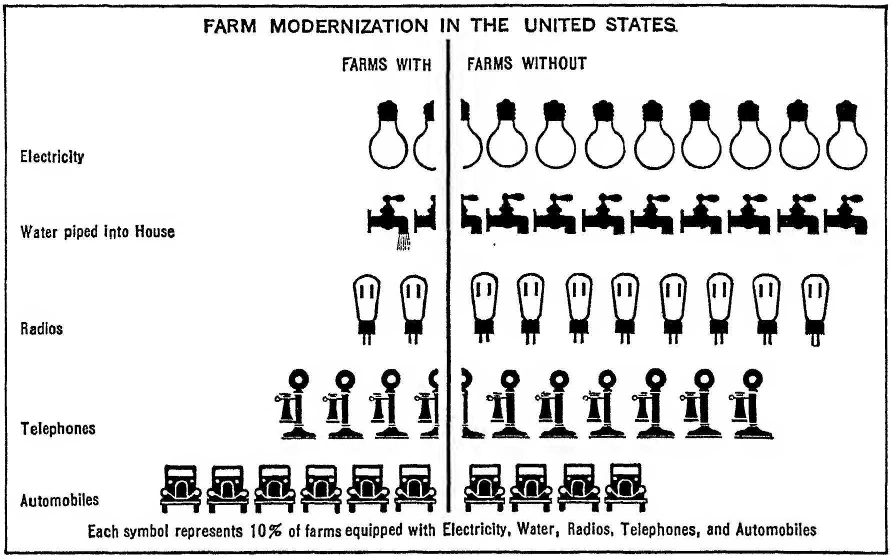
decides to increase his dairy business, it means that a calf, which may not be born for a year, must wait two more years before she begins to give milk. The same is true of beef animals. An apple tree must wait ten years before it comes to full productivity.

Again in the matter of tariff, the manufacturers of America have been able to control legislation in their own interest, getting tariffs that enable them to raise the prices of their commodities. But the surplus of the great staple products of American agriculture—wheat, corn, cotton, beef, pork, apples—are exports. Therefore, they are sold in foreign markets in competition with the whole world. The farm price is set in foreign markets, so on the whole the farmers of the United States buy manufactures at prices enhanced by the tariff, and most of them sell with no advantage from the tariff.

Compare ~~the farmer with the~~ millions of persons ~~engaged in transp~~ortation service. These millions belong to labor unions that obtain high wages, but the farmers with rare exceptions remain unorganized and receive for the products of their labor whatever supply and demand may bring. In most cases the railroad is a monopoly. The farmer and other shippers must ship over the railroad that is near them. The railroads and interstate trucking companies charge rates authorized by the Interstate Commerce Commission, the general level of rates being kept high enough to yield the carriers a profit. The farmer has no such guarantee of price or dividends, and most farms do not pay both wages and interest to the owner who operates them.

Street railways and motor bus lines, the gas companies, and the electric light and power companies have almost complete monopolies. They charge rates which permit close approach to guaranteed dividends, and for years past they have been in a position to overcapitalize and by that process to get millions more of money without rendering any service for it.

The banks deal with money and have



"Organize or be trampled on." For decades the unorganized farmer and unorganized farm worker might well have been called the butt of American economic life. The graph of exports of farm produce earlier in this chapter helps to prove the point. The depression of the 1930's started us making governmental devices toward propping farm prices up. If they should stay up, there would of course be higher cost of living in town and a tremendous increase on farms of the things shown on this graph.

In Denmark, for example, 85% of the farms have electricity. In Switzerland, the per cent is even higher. The limiting factor of our economic system is not power to produce, but power to distribute.

a secured position favored by law, and many of them through various devices make the borrower pay more than the legal rate of interest. This is also true of many finance companies and others who help the farmer to buy things on credit.

The farmers are scattered widely, and, by the nature of their business, agreement among them becomes almost impossible except in special cases with a limited area. They cannot unite themselves into great corporations or combinations, and, as one authority observes, "Powerful combinations have been and are constantly being formed controlling bread, flour, meats, dairy products, breakfast cereals, and all standard foods. Makers of farm machinery, steel and wire, fertilizers, and other manufactures and materials have long controlled nearly everything the farmer has to buy. New combines are now reaching out to control everything he has to sell, through control of the finished produce manufactured from his raw material."[15]

During the acute and prolonged business depression that followed the stock-market crash in October, 1929, the monopolistic and semi-monopolistic industries of this country were able to maintain their prices by curtailing output sharply, by turning off employees, and by reducing their purchases of raw

[15] B. F. Yoakum, President, Empire Bond & Mortgage Corpn., New York, at the United States Institute of Public Affairs, University of Virginia, Charlottesville, Va., August, 1929.

materials. Such action made it difficult for farmers to sell their raw materials and foodstuffs, and farm prices spiraled downward. In an attempt to alleviate the plight of the farmer, Congress passed many laws, some good and some bad. Under the Agricultural Adjustment Act and its successor, the Soil Conservation Act, the production of many important farm products was restricted, the farmers received cash benefits, and the prices of farm products were raised. In a sense, our industrialists, who had been maintaining prices with the aid of tariffs for decades, received a dose of their own medicine when farm prices were raised with governmental assistance. It is the opinion of some authorities that the farm problem would have been much less severe in the past if competitive conditions had been maintained in manufacturing and other industries, and that the future solution of the farm problem will be much easier if the monopoly problem is solved successfully.[16]

There can be no doubt that the Machine Age with all its gadgets has made life easier on the American farm. However, Utopia has not arrived, for only 15% of our farms have the safety and convenience of electricity, 27% have kitchen sinks and drains, 17% have cold water piped into the house, 8% have piped hot water, 9% have flush toilets, 8% have furnace heat, and only 4% have gas or electricity for cooking. In Holland 100% of all farms have electricity, while in Germany more than 90% have this convenience.

We have today the manpower, the animal power, the machine power, and the brain power to produce all and more than we need. If technology and the new machines have helped to bring about overproduction, chaos, and calamity to farming, it is not so much the fault of the Machine Age as it is the failure of our system of distribution, the failure of our economic and social system to make the needed readjustments. Certainly the Machine Age has created social problems so vast that we can scarcely comprehend them. It has also given us new destructions—witness World War II and its efficient devices of destruction. Everyone looks after his own business, but civilization also needs to be looked after.

[16] Paul F. Gemmill and Ralph H. Blodgett, *Economics: Principles and Problems,* Harper & Brothers, Publishers, New York, 1942, p. 334.

. . . 14

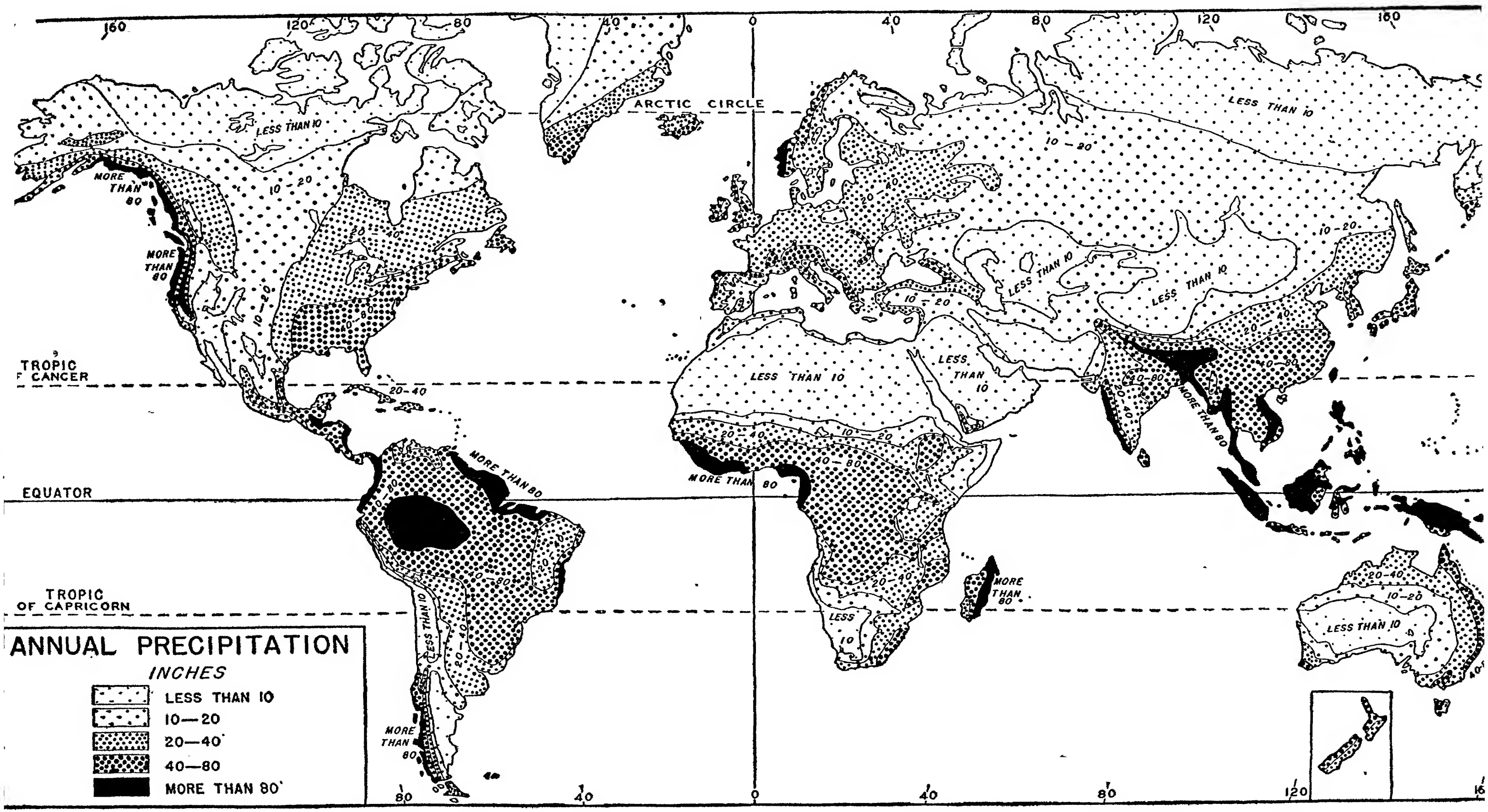
Wheat and Rice: The World's Great Foodstuffs

Bread was long ago called the staff of life, a fact which shows that the Bible was not written in the humid tropics or subtropics where bananas, cassava, yams, or rice were and are the staffs of life. Some cereal food is used among practically all peoples in the temperate zone, and also among the more commercial peoples of the tropics. As population increases in density, meat declines, and cereals increase in importance as an element in man's nutrition. All the cereals are furnished by the grass family. These plants pack starch, gluten, oils, and other elements of nutrition into their seeds to provide for the nourishment of the young plant before it gets its roots well into the earth. This food is equally acceptable to man and to many beasts, and it is furnished to man in various lands by a much larger number of plants than we as a wheat-eating nation would at first expect. Among the world's great foodstuffs, none are so important as wheat and rice.

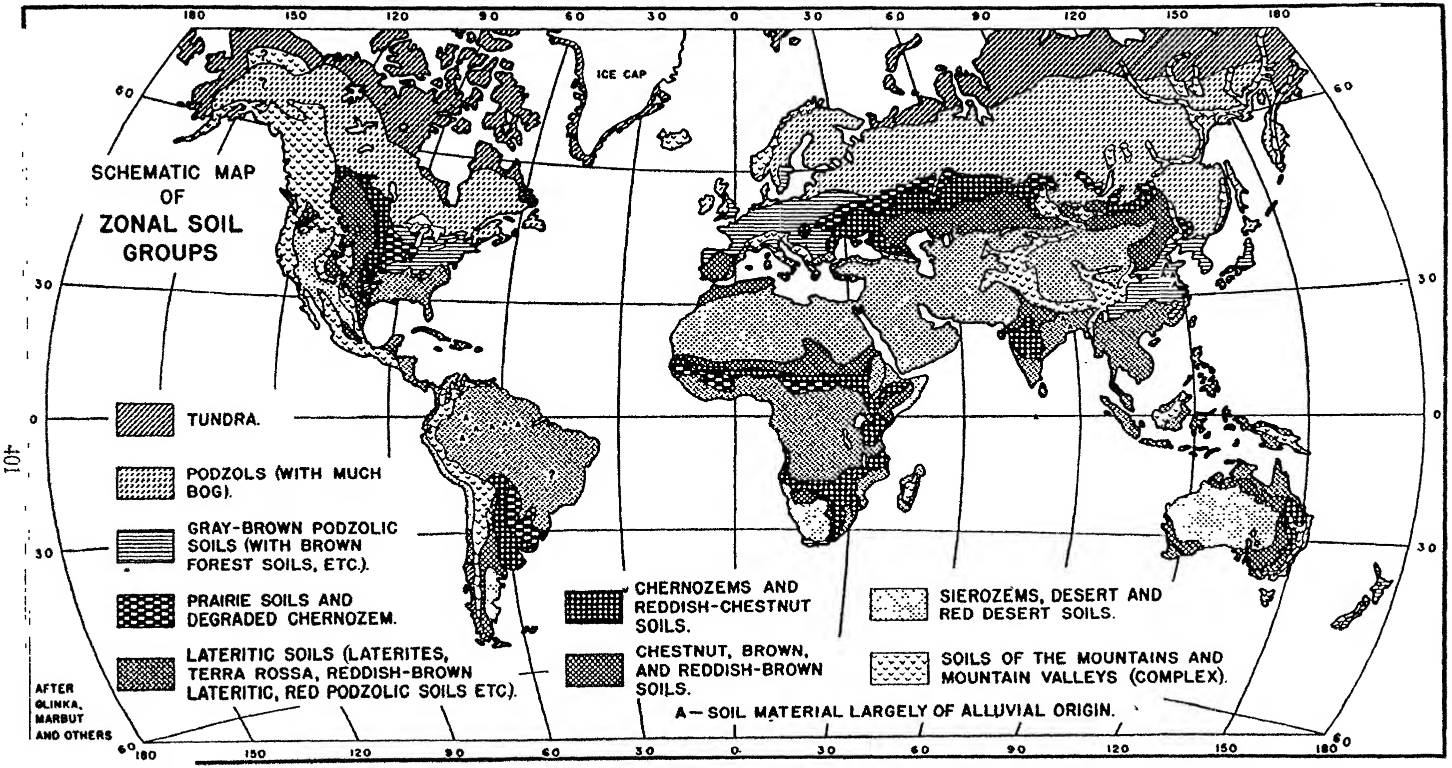
1. The Wheat Plant and Its Climatic Requirements

The Importance of Moisture and Temperature. Wheat is a grass, and in the first part of its growth the plant consists of a tuft of green blades much like any other grass. Later it sends up stalks of straw that support the grain-bearing heads. The number of stalks and heads depends on the size and vigor of the plant, and these are greatly dependent upon the duration of cool, moist weather. If the cool, moist season of formative growth is long, the grass-like development is good and the heads many. Early sunshine that shortens the damp period shortens the grain yield. The formative period is therefore important. In milder climates it usually includes the winter; where the winters are too severe it falls wholly in the spring and summer. Winter wheat, therefore, the wheat of warmer latitudes, is sown in autumn and harvested early the next summer. Spring wheat, the wheat of the lands of cold winter, is sown in spring and harvested at the end of summer. Although wheat grows in many and widely scattered lands and different climates, it must have for the period of its early growth moderate rainfall[1] with rather cool, moist weather, long continued if possible. This must then be followed by warm, bright, and preferably dry weather. Abundance of summer rain is fatal to extensive wheat growth. It causes the plant to

[1] The moisture left in the soil from a period of seasonal rainfall is sufficient in some parts of the Pacific slope to mature a crop of wheat upon which no rain falls.



This map needs to be consulted frequently while reading the wheat chapter, but first compare it carefully with the map of climatic regions in the front of the book. (After Goode, Philip, and Bartholomew.)



Soil science is young. It had to await the discovery that mature soil is a kind of grandchild of climate. For example, a certain type of rainfall makes a grassland. Grass puts out myriad roots in the soil and eventually the roots make the soil black. Hence a belt of black soil between forest and steppe or desert in North America, South America, Africa (two places), Russia, Siberia, and East Australia. This same rainfall that produces grassland is light rainfall, which does not leach the soil unduly. Therefore the soil is rich and the twentieth-century cities that depend upon import bread are drawing largely from these grasslands, with their accumulations of fertility. This map also needs to be compared with the map of world climatic regions, inside front cover.

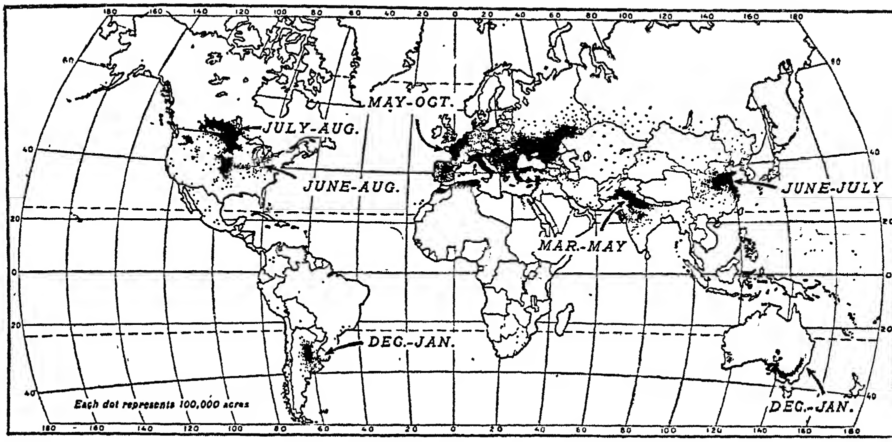
where it is too hot for spring wheat and too cold for winter wheat.

2. *Regions with Good Wheat Climate*

The ideal wheat climate, with a rainy winter and a dry summer, is commonly called the Mediterranean type of climate, because it is characteristic of most countries facing that body of water. This wheat climate exists in all continents in a climatic zone with a western ocean frontage corresponding to the Mediterranean region and produced by the same elements in the world-wind system. This Mediterranean wheat climate is to be found upon the margins of the six arid or desert regions that afflict each of the six continents in the latitude of transition between the zones of trade wind and the prevailing westerly. By all means examine carefully the map of world climate regions in the front of this book.

The Mediterranean Type in Many Lands. This transition land with rainfall varying from the abundant to the scanty, and having a winter maximum, prevails along the northern edge of the Old World desert from Gibraltar through South Europe and North Africa, to Persia. We find it again in South America where the desert extends diagonally from Peru through northern Chile into western Argentina and is bordered by a wheat region on the west in central Chile and on the east in eastern Argentina. Wheat lands border on the cooler edges of the deserts of Central Asia. The same is true of South Africa and Australia, where the desert greatly restricts the area suitable for wheat. In Australia the moisture suffices only in the southeastern and extreme southwestern sections, and her crop varies greatly with the fluctuating rainfall on this desert margin. New Zealand is a small but regular wheat exporter, because its location, a little nearer the South Pole than Australia, permits it to miss the belt of scanty rainfall which roughly follows the tropics of Cancer and Capricorn. New Zealand gets instead the regular rains of the west wind. Australia gets the rain of southern California, and New Zealand that of Washington state. Like England, in a similar latitude and climate, New Zealand has a splendid wheat yield per acre, about 30 to 34 bushels, in contrast with 10 to 12 bushels in Australia.

In the United States, also, we see the wheat regions distributed according to the same conditions. The western part of our country, about 40% to 45% of the whole, is mostly too arid for cultivation, except when irrigated. The district of greatest aridity is in the desert Southwest and the higher but not quite so arid Great Basin. Going from the east toward the arid region we find close to the line of 20 inches of rainfall the most important wheat belt in America, reaching from Texas north through Oklahoma, Kansas, Nebraska, the Dakotas, and Minnesota into Canada. A second belt is found as we go north and northwest from the dry Great Basin, into an area of increased rainfall, which gives the wheat areas of eastern Oregon and Washington. To the west of the Great Basin, across the Sierras in California, is the great valley of that state, long one of the important wheat regions of the country. Its essentially Mediterranean conditions give it a better wheat climate for quality of product than any east of



This map of wheat production average of the years 1930-31, 1934-35 needs to be compared with the soil and rainfall maps. Note the periods of harvest.

the Rockies. The painful fact of inadequate rainfall keeps down the yield, and the area is not large.

In that part of the Mississippi Valley north of Nebraska and its continuation in the plains of west Canada, the winter is too cold for fall-sown (winter) wheat, but a fortunate rainfall distribution permits the planting of wheat in spring. The rather light rainfall of 15 to 20 inches has a maximum in early summer or midsummer, which promotes the grassy growth of wheat. A *hot* June injures this wheat and sets the southern limit of the region. The wheat usually ripens well in the drier late summer. This makes the plains in the center of North America one of the most promising granaries of the twentieth century. But the promise of great production in the next decades is due more to great area and to the impracticability of raising other important cash crops rather than to any perfection of climate.

This is really a marginal land with a small margin of safety arising from the painful frequence of drought, hot Junes, frost, hail, and pests of grasshoppers and sometimes rust and scab. Further uncertainties of income arise from fluctuating price depending on production of competing regions in every continent. This region, however, has a fertile soil, the black prairie soil of continental interiors.[3] It is really the advance of agriculture into these black soil plains of

[3] "After a long period of floundering with unclassified soil facts it has recently been discovered by Russian students that the development of earth or rock material into soil goes through a cycle—young, mature, old. The startling fact is that climate dominates the character of the *mature* soil almost without regard to its geologic origin. . . . The black prairie soils of the middle western regions of the United States furnish an illustration of the theory of climatic causation of soils. Between the wet forest of eastern Texas and the subhumid and treeless northwestern Texas, and also between the humid forests of Indiana and the semi-arid sagebrush lands of western Nebraska, there is a transition in rainfall and in natural vegetation. Between each of these two regions of rainfall contrasts and their resulting vegetation contrasts is a wide belt of grassland. Grassland makes black soil—black-waxy, as it is called in Texas. Of similar origin are the black wheat lands of central Kansas, eastern Nebraska, eastern Dakota, Manitoba, Saskatchewan and Alberta. These black soils are a transition belt between the eastern and northern forest (humid) and the sagebrush plains (dry). Similar zones of transition in rainfall, in vegetation and in soil are found in the black land grain fields of other continents. The limited black land area in Argentina has made that country a

continental interiors that has done so much to permit the easy feeding of city populations with wheat bread and their rapid increase since 1870.

3. *The Introduction and Breeding of New Wheats*

Progress in the Northwest. Still further extensions of the world's wheat areas may be expected through our knowledge of plant breeding and production of new varieties. Since we have come into possession of Mendel's Law, the usable working law of heredity,[4] we are able to change wheat and most of the other crops grown by man. Progress in plant breeding has been rapid since 1910. An occurrence in the Northwest is illustrative of the new-found ability that is destined to enrich every land in the world. On the lava plains of the eastern part of Washington, the practically rainless summer permits the farmers to let the wheat stand for a month after it is ripe. The harvesting can accordingly be extended over a period of several weeks, and comparatively few hands can thus take care of vast farms. It so happened, however, that the best yielding variety permitted many of the grains to scatter out of each head and fall to the ground before it was cut. The rival variety that held its grains tightly was so tender as to be injured one year in three by the frosts, which follow periods of warmth and growth, in this land of open winter where wheat is usually sown in the fall. An experimenter at the agricultural experiment station in the state of Washington crossed these two varieties, and produced a third variety which has the frost-resisting qualities of one and the grain-holding qualities of the other, thus permitting large extension of wheat growing on the wide fertile lava plain of the Columbia Basin, which now averages about 21 bushels per acre, while the average of the whole United States is but 13.5 per acre. Yet even in this land of lava soils, where wheat occupies four-fifths of the total crop acreage, declining fertility and the need of conserving soil moisture make it necessary to leave a field lie fallow in an occasional year.[5]

The possibilities loom large when we think of combining scientific plant breeding with the raw material produced by searching the climatic hard spots of six continents.

For example, the *Yearbook of Agriculture* (1936, p. 216) states:

"The first introduction of hard red winter wheats, now grown in a vast area in the Southwest, were made by a small group of Menonites who emigrated from

grain exporter. In Eurasia the Black Belt sweeps from the Black Sea through Russia and far into Siberia. Australia has a little strip, as has the Sudan. This black soil is the prime grain land of the world."—J. Russell Smith, "Agriculture: General Problems," *Encyclopaedia of the Social Sciences,* vol. 1, The Macmillan Co., New York, 1930, pp. 593-594. See Louis A. Wolfanger, *The Major Soil Divisions of the United States: A Pedologic-Geographic Survey,* John Wiley & Sons, Inc., New York, 1930.

[4] Donald F. Jones, *Genetics in Plant and Animal Improvement,* John Wiley & Sons, Inc., New York, 1925.

The Yearbook of the U. S. Department of Agriculture, 1936, contains a wealth of examples of this new alchemy which promises so much.

[5] Specialization in wheat and continuous cultivation for more than 50 years have reduced the organic matter in the soil by at least 35% and the nitrogen by 25%, with a resultant reduction in the moisture-holding capacity of the soil and an increase in erosion.—O. E. Baker, "Agricultural Regions of North America, Part XI, The Columbia Plateau Wheat Region," *Econ. Geog.*, vol. 9, April, 1933, p. 188.

southern Russia and came to the middle of the Great Plains in the United States. In 1873 they settled in central Kansas, principally in the vicinity of Newton and Halstead. With them they brought seed of *Turkey wheat,* and they found it to be well adapted to the new country. The wheat attracted only local attention, however, until Carlton, one of the pioneers in plant improvement, discovered it and recognized its resistance to drought and its good yields under adverse conditions."

Please note that this episode was essentially accidental. It will take generations of peaceful exploring and *breeding* to get the full results for a few score species of crop plants.

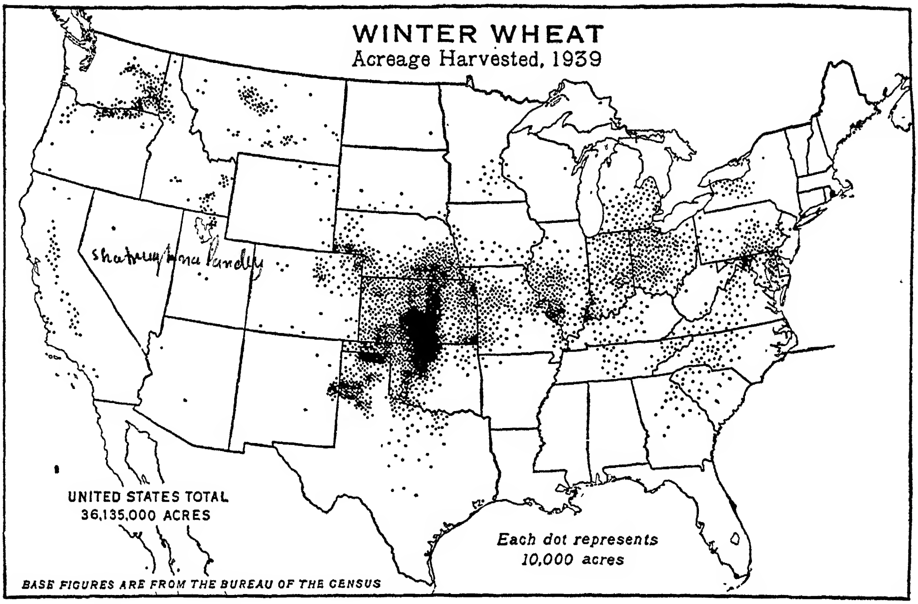
This Turkey wheat produces nearly a quarter of the United States crop, and it now has several Russian cousins in the field on the *arid edge.*

It should be noted that nearly all of the wheat areas are on the edge of *aridity.* Little has been done toward invading the humid edge, but here is a case, perhaps a sample of what may be a large development on a rundown and wornout cotton plantation about 40 miles southwest of Augusta, Georgia (lat. 33° N.); seventy cotton-growers have given way to fifteen wheat-growers, using a new rust-proof wheat. In August, the wheat field is a solid mass of 3-foot croatalaria, a tropic legume with the characteristic nitrogen-gathering bacteria. In October, the croatalaria seed ripens, and giant discs chop the mass into the earth. Wheat seeding follows. Combines harvest a good crop of wheat in May and June. A few million plants of croatalaria have seeded themselves on each acre, and are ready to take possession. There you are! A two-crop rotation with wheat every year and humus increasing from the automatic crop of green fertilizer and cheap chemicals. Our Cotton Belt is a land of potent possibilities of increase if we can use it in the future without destroying it acre by acre as we have in the past.

Several varieties of Australian wheat have been introduced into the Pacific coast states. Although grown as spring wheats in Australia (also in Washington and Oregon) they have been successful as winter wheats in California. Some of the transplanted Australian strains have produced higher yields than the old varieties and have proved superior for milling and bread-making purposes.

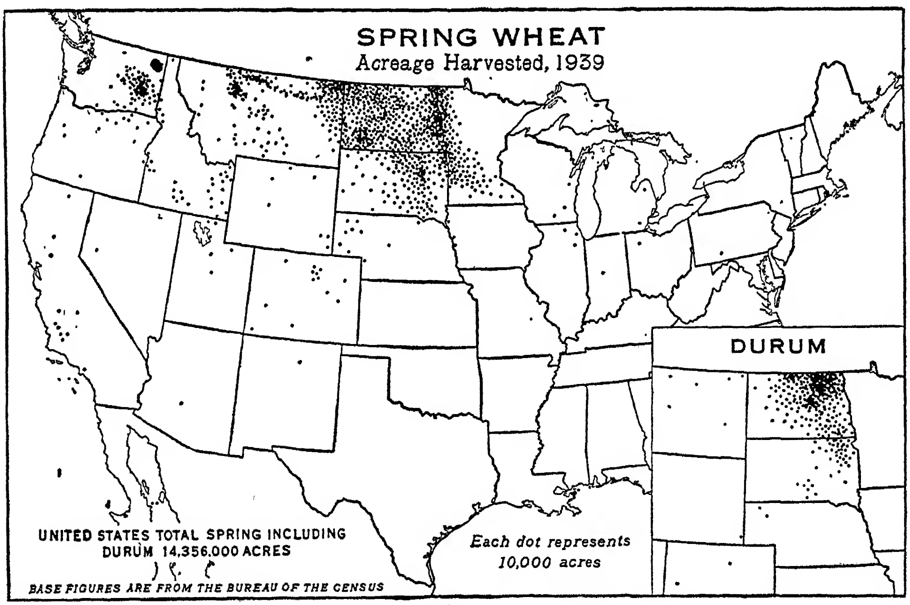
Progress in the Spring Wheat Belt. The great spring wheat industry of the Dakotas, Minnesota, Montana, Manitoba, Saskatchewan, and Alberta was founded in the middle of the last century when a variety of hard red wheat, known as Red Fife, was introduced from Scotland into Canada and thence into the United States.[6] For decades Red Fife remained the king of wheats throughout the Spring Wheat Belt, yielding supremacy in 1918-19 to Marquis, a cross between Red Fife and

[6] This variety of wheat originally grew in the Galician section of Poland and was taken to Germany and later to Scotland. It was David Fife of Otonabee, Ontario, Canada, who first obtained a small sample of this wheat from a friend in Glasgow. He sowed it in the spring, but it proved to be winter wheat. A single plant of spring wheat developed out of the lot, and this was saved and increased. Cultivation of Red Fife began in the United States in 1860 when J. W. Clark, a Wisconsin farmer, had an excellent crop. The efficient and large-scale use of hard red spring wheat, however, had to await the invention of the roller mill and the purifier, which could handle the grain effectively.—U. S. Dept. of Agriculture, *Yearbook of Agriculture, 1936,* Washington, 1936, pp. 214-215. Note: This yearbook and the 1937 edition contain excellent summaries of outstanding progress in plant breeding.



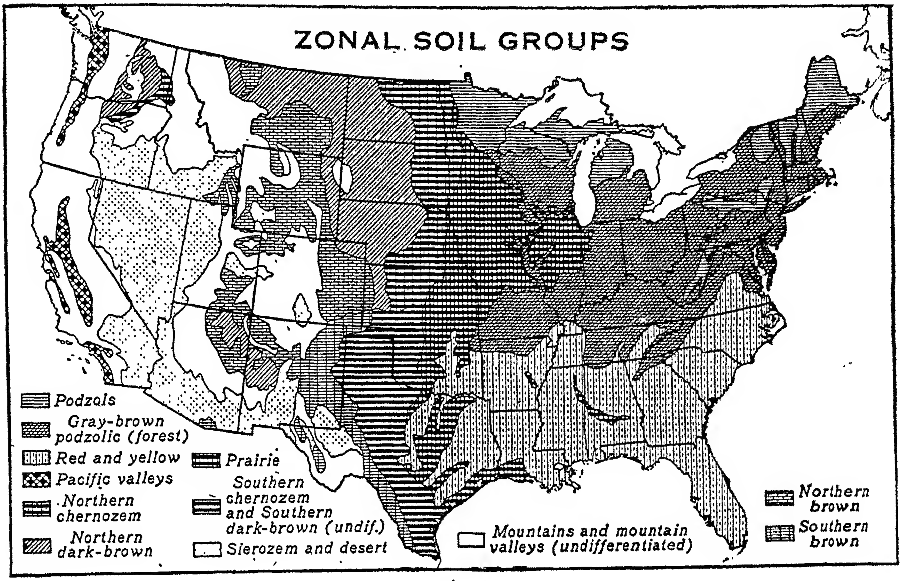
A

Winter wheat is a part of a crop rotation and the nurse plant for grasses east of Kansas, but in the prairie area of central Kansas it becomes almost a one-crop agriculture.



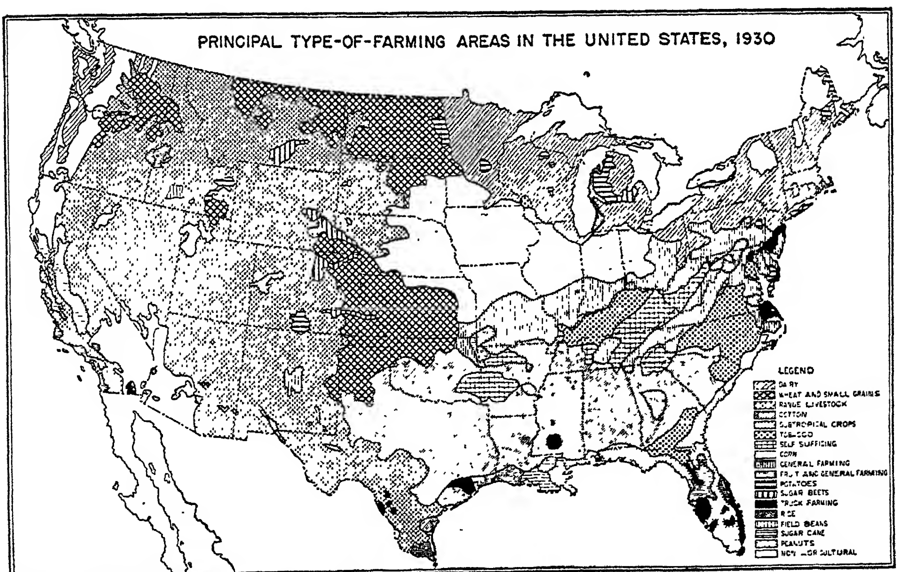
B

Spring wheat is largely the product of the subhumid grasslands. Note the separation between spring wheat and winter wheat.



A

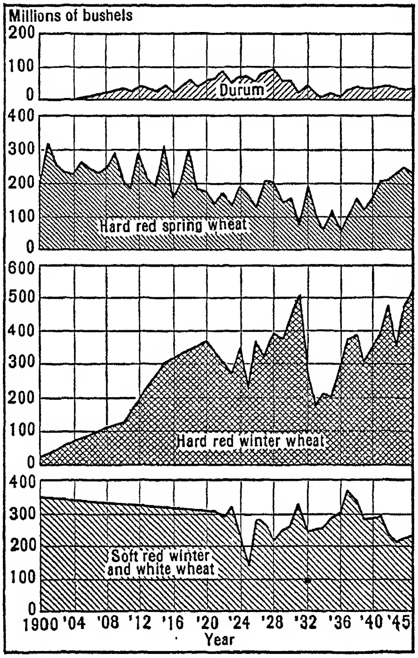
This map of zonal soil groups in the United States shows the influence of grassland as a factor in soil coloration.



B

The type-of-farming areas in the United States show how the various combinations of circumstances have distributed the crops on our soils.

Hard Red Calcutta of India, which was developed in Canada and introduced into this country in 1912. For 20 years Marquis retained the universal approval of farmers, grain traders, and the milling and baking industries, because this



Wheat production in the United States, according to classes, shows that durum, the great sensation of a few decades ago, has been surpassed by some of the newer results of plant breeding. Hard red winter has gained on Hard red spring. (Data from *The Northwestern Miller.*)

early maturing and drought-resistant wheat escaped rust at first, gave high yields, and proved excellent for milling and bread-making. As a result of great damage from stem rust in 1935, 1937, and 1938, Marquis has been largely replaced by its offspring, Ceres and Thatcher wheats. Thatcher wheat was first distributed to the farmers in 1934 and is now the dominant wheat in the Spring Wheat Belt, but in areas where leaf rust has appeared Thatcher is giving way to Rival, Pilot, Renown, and Regent wheats which are apparently immune to both stem and leaf rust.

Another immigrant is drought-resistant durum wheat, which was introduced by Russian settlers in North Dakota in 1898. Two years later the Department of Agriculture imported from southern Russia the Kubanka variety which dominated durum production until 1939, when it was surpassed by Mindum, an improved variety. Since durum wheat contains a higher proportion of protein than any other wheat, it is used in the manufacture of macarona, spaghetti, and other alimentary pastes. Almost all durum wheat in this country is produced in the Dakotas.

The introduction of new varieties gives new *materials* for the plant breeders to use. Plant explorers have scoured the far corners of the earth in search of plants adapted to particular environments and uses, and all branches of the wheat industry have benefited greatly from plant importation and breeding. The United States Department of Agriculture has obtained over 8,000 foreign introductions of wheat from more than 50 countries and has viable seed of nearly 5,000 of these. Plant introduction as a method of wheat improvement reached its peak in the closing years of the nineteenth century, and since then our cerealists have achieved greatest progress through pure-line selection and hybridization.

What has been said here about breeding wheat suggests that wheat breeding is in its infancy, and further that it is applicable to almost every plant that is now a crop and to hosts that are not yet cultivated.

Classes of Wheat. The two major groups of wheat are fall-sown or winter wheat and spring wheat, the former comprising more than 75% of the world's annual output and between 70% and 80% of all wheat produced in the United States. Although more than 300 varieties are known to be grown in this country, grain traders and the federal government recognize five main classes of wheat: (1) hard red spring, (2) durum, (3) hard red winter, (4) soft red winter, and (5) white. Federal standards also provide for a class known as mixed wheat.[7] These meet the varying demands of the makers of crackers, biscuit, pastry, bread in many forms, poultry food, spaghetti, and macaroni. Durum of the Dakotas, the wheat of macaroni and spaghetti makers, occupies only about 5% of our total wheat acreage and is least important among the major classes of wheat.[8]

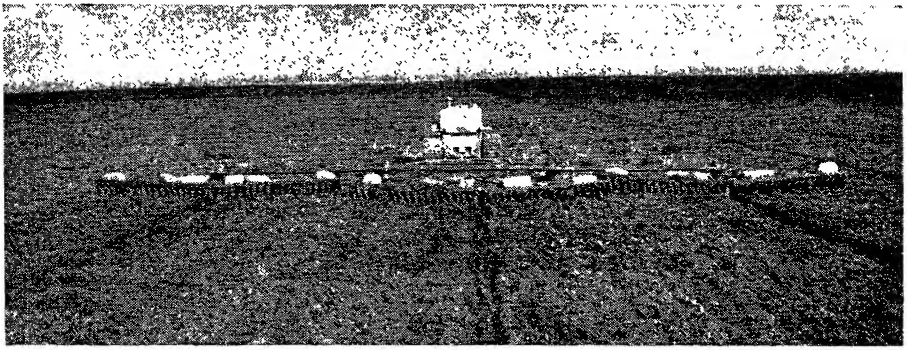
4. *The Impact of Modern Machinery upon Wheat Production*

Flour Milling. Two types of greatly improved machinery have had a profound effect upon wheat production, the machines of the flour manufacturer and those of the wheat grower. For many years the technique of milling remained virtually unchanged, wheat being ground into flour between pairs of circular millstones, the upper stone being turned by a vertical axle while the lower or "nether stone" remained stationary. When farmers began to grow wheat in Wisconsin, Minnesota, and the Dakotas, climate compelled them to grow hard spring wheat or none at all, but the wheat was so hard and so brittle that for many years it could not be satisfactorily ground. The bran broke up and mixed with the flour. It made a wholesome bread but not one pleasing to the eye, and unfortunately for health we eat too largely with our eyes. Therefore, the new hard wheat made "poor" flour, it brought poor prices, and the lands upon which it was grown were in low esteem. The importation of the roller or gradual-reduction process from Europe in the eighteen-seventies solved the milling problem in this country and helped to bring about a great expansion of hard wheat production northward through Minnesota and the Dakotas into Canada and southward through Kansas and Oklahoma into Texas.[9] In this process wheat is crushed between revolving fluted iron rollers about 9 or 10 inches in diameter and 2 or 3 feet long, and it is gradually reduced into fine flour by repeated crushings. Approximately 70% of the wheat is converted into various grades of flour, the remainder consisting of

[7] When wheat is mixed, its utility may be impaired, but mixtures are often unavoidable. Various types may be accidentally mixed in marketing. In some areas when fall-sown wheat has been practically ruined during the winter, the farmers may replant the fields with spring wheat, resulting in a considerable mixture when the crop is harvested.

[8] Our total harvest of 946 million bushels in 1941 included 394 million bushels of hard red winter, 212 million bushels of soft red winter, 206 million bushels of hard red spring, 91 million bushels of white, and 43 million bushels of durum wheat.—U. S. Dept. of Agriculture, *Agricultural Statistics, 1942,* Washington, 1942, pp. 17, 19.

[9] For a discussion of the development of the gradual-reduction process in France, Switzerland, and Hungary and its later adoption in the United States, see James C. Malin, *Winter Wheat in the Golden Belt of Kansas,* University of Kansas Press, Lawrence, Kans., 1944, pp. 188-197, and Evan B. Alderfer and Herman E. Michl, *Economics of American Industry,* McGraw-Hill Book Co., Inc., New York, 1942, pp. 421-428.



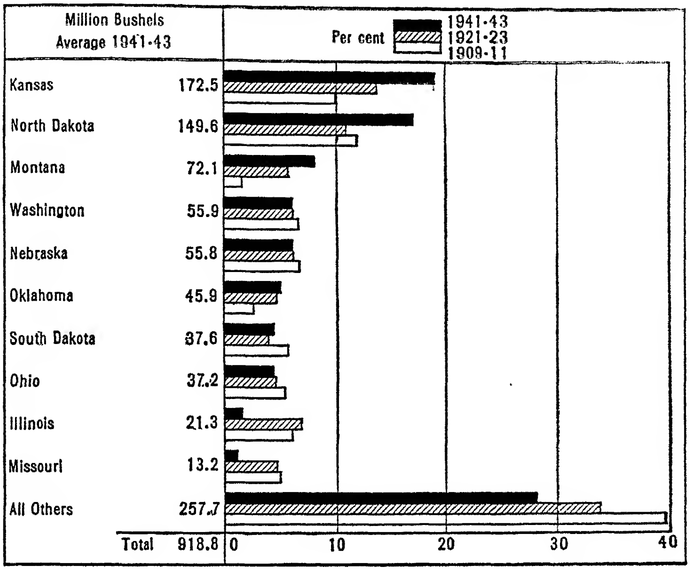
A Caterpillar tractor drawing a battery of disks that tear up 63 feet of wheatland on the Great Plains section of Colorado. Working in third gear, the machine does 20 acres an hour on five gallons of 8¢ petroleum fuel. Fuel cost per acre—2¢. Exit Old Dobbin! He means well, he works hard, he sweats valiantly, but a hundred of them could scarcely do this, and who would feed them during the nine or ten months' vacation? Note the farm buildings on the distant skyline, which is unbroken by trees.

bran and other by-products. In the United States virtually all flour is now milled by the efficient gradual-reduction process.

Machinery on the Farm. The methods of producing wheat have been made much cheaper and easier by mechanical inventions. Eighteenth-century wheat was cut in the Scriptural way, by sickle held in one hand of the laborer, while he grasped a few heads of wheat in the other. Then came the cradle invented in New England in 1806. It was a kind of scythe provided with fingers above the blade to catch and throw into an even row the straw it cut. The cradle was the main dependence of the United States through the first half of the nineteenth century. In 1831, Cyrus McCormick of Virginia invented the first successful reaper, which cut and dropped the grain in bundles to be bound by hand. In 1878 John Appleby invented a twine binder that tied the bundles with twine; this replaced the unsatisfactory wire binders already in use and increased eight-fold the speed in harvesting. Reapers were perfected that would tie the bundles and carry and drop them in piles where the shocks are to be made. One of these machines with a tractor and a driver has no difficulty in performing with comparative ease as much work as was done 100 years ago by 5 to 10 men working arduously with cradles and rakes. As wheat cutting is now merely the driving of tractor and the adjusting of levers on the reaper, the work is occasionally done by women.[10]

Wherever wheat is grown on a large scale, the huge combined harvester and thrasher is now a common sight. On the great wheat ranches of the Columbia Basin, where the grain dries out on the stalk in the very dry summer, monster machines cut, thrash, clean, sack,

[10] The glamor of wheat harvest is gone from many an eastern American countryside. The reaper has made a commonplace occurrence of an event that was talked about for months, prepared for for weeks, and which furnished the great athletic event of the year, where strong men sent each other to the shade in contests more grueling than the Marathon of the Olympiad. The man who could cut 5 acres of wheat per day with a cradle for six consecutive days was a *man.*



The record of wheat production by states for this thirty-year period shows that wheat is going west. Compare Missouri and Ohio with the Great Plains States.

and weigh the wheat without the touch of human hands. Prior to the coming of the tractor, these harvesting giants were driven by steam or were drawn through the waving wheat fields by spans of 25 to 35 straining, sweating horses. Men are still living in the United States who in their youth helped thrash by driving horses around and around upon the sheaves that their feet might shatter out the grains upon the thrashing floor in true Scriptural fashion. In a similar method the horses drag a rolling stone around the thrashing floor. Such primitive harvesting methods are still employed in parts of the Balkan countries and other backward areas. In more progressive regions, under the influence of high wages, the engine-driven thrasher does nearly all the work. In the United States, it is common for one of these machines to thrash a thousand bushels of wheat per day and be taken at evening to the next farm by its own traction engine. These revolutionary improvements in wheat production cheapened its labor cost from 133 minutes of human labor per bushel in 1830 to less than 10 minutes in 1940. The prevalent machine today is the combine which cuts and thrashes as it goes.

The machinery for planting, harvesting, and thrashing wheat has also been adapted, with minor changes, to do the same work for the other small grains—rye, oats, barley, and buckwheat. The cheapening that results from the easier production permits wheat to become more universally used as food. It is now eaten by many people in the southern United States who previously made a larger use of corn. Prior to World War I, wheat had begun to replace the standard rye loaf in central Europe. Even the Chinese and Japanese are increasing their use of it as a luxury to replace

TABLE 22

Proximate Composition of American Food Materials

E.P.: Edible portion.
A.P.: As purchased.

Food	Basis	Constituents of the edible portion										Fuel value per lb., calories
		Refuse, %	Water, %	Protein, %	Fat, %	Ash, %	Carbohydrates				Acid, %	
							Total, %	Fiber, %	Sugars, %	Starch, %		
Almonds: Dried	E.P.	..	4.7	18.6	54.1	3.0	19.6	2.7	4.4	...	...	2,900
Apples: Fresh, all	A.P.	12	74.0	.3	.4	.3	13.0	.9	...	...	...	260
Apricots: Fresh	A.P.	6	80.3	.9	.1	.6	12.1	.6	...	...	...	240
Asparagus: Fresh	A.P.	25	69.8	1.6	.2	.5	2.9	.5	...	...	..	90
Bacon: Raw, medium	A.P.	6	19.0	8.6	61.0	4.0	1.0	...	...	...	...	2,670
Bananas: Fresh	A.P.	33	50.1	.8	.1	.6	15.4	.4	...	...	...	300
Barley: Whole	E.P.	..	10.2	12.8	2.1	2.1	72.8	2.7	...	...	...	1,640
Beans: Snap green	A.P.	10	80.0	2.2	.2	.7	6.9	1.3	...	...	...	170
Beans: Dry seeds, all	E.P.	..	10.5	22.0	1.5	3.9	62.1	3.9	3.6	35.8	...	1,585
Beets: Fresh	A.P.	25	65.7	1.2	.1	.8	7.2	.7	...	...	..	155
Blueberries: Fresh	E.P.	..	83.4	.6	.6	.28	15.1	1.2	9.7	...	.67	310
Brazil nuts	E.P.	..	5.3	14.4	65.9	3.4	11.0	2.1	1.5	2.2	...	3,150
Breads: Rye, American	E.P.	..	37.6	8.9	2.0	1.8	49.7	.5	...	...	...	1,145
Breads: White, commercial	E.P.	..	35.9	8.5	2.0	1.3	52.3	.3	...	...	...	1,185
Butter	E.P.	..	15.5	.6	81.0	2.5	.4	...	...	..	...	3,325
Cabbage: Fresh	A.P.	27	67.5	1.0	.1	.5	3.9	.7	..	..	...	90
Chocolate creams	E.P.	..	9.0	4.0	14.0	1.0	72.0	...	...	...	...	1,950
Carrots: Fresh	E.P.	..	88.2	1.2	.3	1.02	9.3	1.1	7.5	..	...	205
Cashew nuts	E.P.	..	4.1	19.6	47.2	2.7	26.4	1.0	6.8	10.7	...	2,760
Celery: Fresh	A.P.	37	59.0	.8	.1	.7	2.4	.4	...	...	...	65
Cheese: Cheddar	E.P.	..	39.0	23.9	32.3	3.1	1.7	...	...	...	...	1,785
Cherries: Fresh	A.P.	6	78.0	1.0	.5	.5	14.0	.3	..	..	...	290
Chestnuts: Fresh	E.P.	..	53.2	2.8	1.5	1.0	41.5	1.1	6.4	14.8	...	865
Chickens: Roasters	A.P.	23	50.8	15.6	9.7	.8	0	...	...	...	...	680
Chocolate: Unsweetened	E.P.	..	2.3	(5.5)	52.9	3.2	(18.0)	2.6	...	...	..	2,585
Clams: Round	E.P.	..	79.8	11.1	.9	2.3	5.9	...	...	...	...	345
Cocoa: Plain, all	E.P.	..	4.3	(9.0)	18.8	5.2	(31.0)	4.8	...	...	...	1,495
Coconut: Fresh	A.P.	26	44.5	1.9	18.5	.7	8.4	1.7	...	...	...	940
Cod: Raw	A.P.	52	39.6	7.9	.2	.6	0	...	...	...	...	150
Corn: Field dry	E.P.	..	11.0	10.0	4.3	1.3	73.4	2.1	...	...	...	1,690
Canned	E.P.	..	76.0	2.5	.9	1.0	19.6	.4	...	...	...	440
Cottonseed flour	E.P.	..	6.8	42.3	10.8	5.8	34.3	4.1	...	2.2	...	1,830
Cowpeas: Dry	E.P.	..	10.6	22.9	1.4	3.5	61.6	4.2	5.9	23.8	...	1,590
Dasheens: Fresh	A.P.	16	55.9	2.4	.2	1.2	24.3	.6	...	...	...	495
Dates: Fresh and dried	A.P.	13	17.0	1.9	.5	1.6	65.6	2.1	...	...	...	1,245
Eggs: Hen, fresh, stored or frozen	A.P.	11	65.9	11.4	10.2	.9	.6	...	...	...	...	635
Figs: Dried	E.P.	..	24.0	4.0	1.2	2.4	68.4	5.8	55.0	...	.6	1,365
Fish: Raw, Class 1, medium composition	E.P.	..	77.2	19.0	2.5	1.3	0	...	...	...	...	445
Goose, domesticated: Fresh	A.P.	41	30.1	9.7	18.6	.5	0	...	...	...	...	930
Grapefruit: Fresh, all	A.P.	34	58.6	.3	.1	.3	6.7	.2	...	...	...	130
Grapes: Fresh, American type	E.P.	..	81.9	1.4	1.4	.45	14.9	.5	11.5	...	1.21	355
Lamb: Leg, trimmed, thin	E.P.	..	71.0	18.4	9.1	1.0	0	...	...	...	...	710
Lard	E.P.	..	...	...	100.0	...	...	...	...	...	...	4,080
Lentils: Dry, whole	E.P.	..	11.2	24.7	1.0	3.2	59.9	3.3	...	...	...	1,575
Liver: Fresh, calf	E.P.	..	70.8	19.0	4.9	1.3	4.0	...	...	...	...	620

TABLE 22 (*Continued*)

Proximate Composition of American Food Materials

E.P.: Edible portion.
A.P.: As purchased.

Food	Basis	Constituents of the edible portion										Fuel value per lb., calories
		Refuse, %	Water, %	Protein, %	Fat, %	Ash, %	Carbohydrates				Acid, %	
							Total, %	Fiber, %	Sugars, %	Starch, %		
Meat and poultry: Cooked	E.P.	..	63.0	30.0	6.0	1.2	0	...	...	...	...	790
Milk: Cow, fresh, whole	E.P.	..	87.0	3.5	3.9	.7	4.9	...	...	.	...	310
Molasses, cane: Light	E.P.	..	24.0	...	...	3.0	65.0	...	65.0	...	..	1,180
Mulberries: Fresh	E.P.	..	82.8	1.2	.6	.84	14.6	2.0	9.4	...	.95	310
Oatmeal or rolled oats: Dry	E.P.	..	8.3	14.2	7.4	1.9	68.2	1.2	...	..	..	1,795
Oleomargarine	E.P.	..	15.5	.6	81.0	2.5	.4	...	...	...	...	3,325
Onions: Fresh, all	A.P.	6	82.2	1.3	.2	.5	9.8	.8	...	..	...	210
Orange juice: Fresh, all	E.P.	..	...	..	...	...	10.1	..	9.0	...	1.16	...
Peaches, Fresh, all	E.P.	..	86.9	.5	.1	.47	12.0	.6	8.8	...	.64	230
Peaches: Dried	E.P.	..	24.0	3.0	.6	3.0	69.4	3.5	51.0	...	3.0	1,340
Peanuts: Roasted in shell	E.P.	..	2.6	26.9	44.2	2.7	23.6	2.4	...	..	...	2.720
Peas: Fresh, shelled, all	E.P.	..	74.3	6.7	.4	.92	17.7	2.2	3.2	8.2	..	460
Peas: Dry, whole	E.P.	..	11.6	23.8	1.4	3.0	60.2	5.4	..	45.1	...	1,580
Pecans	E.P.	..	3.0	9.4	73.0	1.6	13.0	2.2	3.9	.0	...	3,385
Persimmons: Native	E.P.	..	64.4	.8	.4	.9	33.5	1.5	18.9	..	.19	640
Pork, cured: Raw, Ham, medium	A.P.	13	37.0	14.7	30.0	4.7	(.3)	...	...	..	...	1,510
Potatoes: Fresh	E.P.	..	77.8	2.0	.1	.99	19.1	0.4	.9	14.7	...	385
Potato flour	E.P.	..	7.0	8.5	.5	4.0	80.0	1.7	...	...	..	1,625
Raisins	E.P.	..	24.0	2.3	.5	2.0	71.2	...	63.0	...	1.8	1.355
Rice: Brown, uncooked	E.P.	..	12.0	7.5	1.7	1.1	77.7	0.6	...	...	...	1,615
Salmon: Pacific, canned	E.P.	..	67.4	20.6	9.6	2.4	0	...	...	...	...	765
Sauerkraut: Bulk	E.P.	..	91.2	1.3	.2	2.4	4.9	1.4	.3	...	1.6	120
Sausage: Frankfurt, all meat	E.P.	..	61.1	14.1	20.8	2.8	0	..	..	..	...	1,100
Sirups: Corn, table mixture	E.P.	..	25.0	...	...	.6	(74.0)	...	...	...	...	1,345
Soybeans: Dry seeds	E.P.	..	7.5	34.9	18.1	4.7	(12.0)	5.0	8.4	2.1	...	1,590
Soybean sprouts	E.P.	..	82.3	8.5	1.8	1.07	6.3	.9	...	...	...	340
Soybean milk	E.P.	..	92.6	3.4	1.5	.5	2.0	.0	.7	...	...	160
Sugars: Granulated	E.P.	..	.5	...	...	...	99.5	...	99.5	...	..	1,805
"Swedish health bread" or rye	E.P.	..	6.8	12.9	1.6	3.3	75.4	1.8	...	...	...	1,665
Sweet potatoes: Fresh	E.P.	..	68.5	1.8	.7	1.07	27.9	1.0	5.4	20.2	...	565
Tomatoes: Fresh, red	E.P.	..	94.1	1.0	.3	.57	4.0	.6	3.4	...	.51	105
Turkey: Fresh, med. fat birds	E.P.	..	58.3	20.1	20.2	1.0	0	...	..	...	...	1,190
Turnips: Fresh	E.P.	..	90.9	1.1	.2	.73	7.1	1.1	4.6	...	..	155
Walnuts: Black	E.P.	..	2.7	18.3	58.2	2.1	18.7	1.9	...	...	..	3,045
Wheat flours: straight, all types	E.P.	..	12.0	11.2	1.1	.5	75.2	.4	...	...	...	1,615
Wheat: Bran flakes	E.P.	..	6.2	13.0	1.9	4.0	74.9	3.1	...	...	...	1,670
Wheat Germ: Commercial	E.P.	..	11.0	25.2	10.0	4.3	49.5	2.5	...	...	...	1,765

Selected from Circular No. 549, U.S.D.A., Charlotte Chatfield and Georgian Adams.

The Machine Age comes to the wheat field—process #2. The Caterpillar draws a battery of drills, seeding a 50-foot strip as it crosses the level plain. Three gallons of fuel per hour suffice to seed this 50-foot strip.

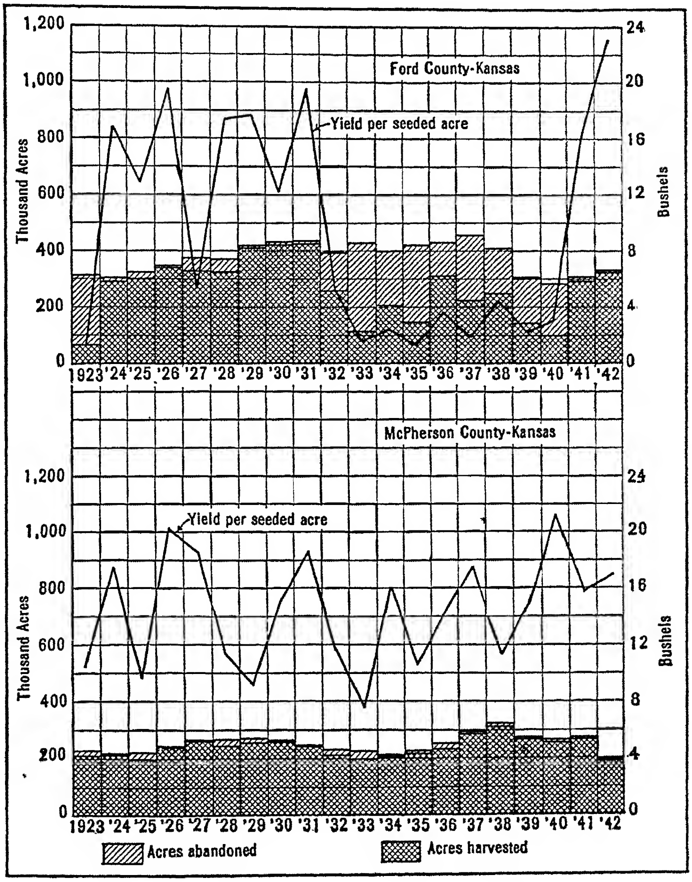
partially their cheaper foods of barley, rye, millet, corn and the more expensive rice.

5. *Wheat, a Crop Well Adapted to Sparsely Populated Regions*

Yield and Production of Wheat in New Countries. It is a peculiar fact that the world's greatest wheat exports are produced in regions of comparatively low yield per acre, and in regions that do not have the ideal wheat climate (see Table 23). This is because wheat, where it can be grown in treeless countries, is a good frontiersman's crop. With the aid of modern agricultural and transportation facilities, wheat is a money crop easily grown. A single farmer can in some cases raise 400 or 500 acres of wheat, whereas 100 acres of corn is now attained by tractor aid in the large amount of cultivation required by this intertilled crop. No man can milk or care for more than a very limited number of dairy cows. In contrast, the wheat farmer merely watches his crop grow until harvest time. The amount of wheat that he can grow is limited only by the amount that he can harvest, and in the vast fields of sparsely populated regions this labor problem has been largely solved by the use of power-driven machinery. Furthermore, wheat has good keeping qualities, is easily shipped, is in universal demand. It is of more value in proportion to its bulk than hay or any other temperate zone grain. It grows well in a greater number of places than either corn or oats. Once it is safely sheltered near a railroad, it can be marketed many months later, thousands of miles away. These advantages of wheat as a money crop often make it the first and most profitable thing that can be grown by the new settler upon an open plain after the railroad is within reach, even though the average yield per acre be low. The distribution of the world's wheat crop is a fine illustration of the fact that products are often grown in places that are not best suited to them. Indeed, because of insufficient rainfall or an inadequate

market for other crops, in many areas wheat is often the only important cash crop that can be grown.

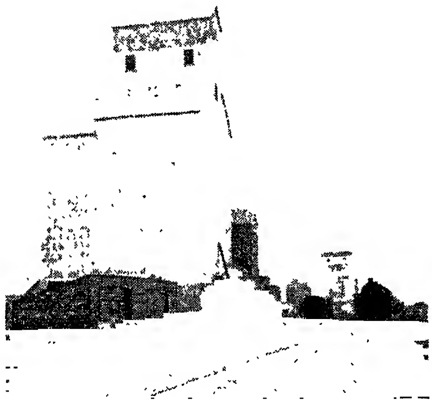
The world's chief wheat exports are grown upon such newly accessible plains in the Mississippi, Missouri, and Red River valleys of the United States, in western Canada, east central Argentina, southern Russia, the Danube Basin, and southeastern Australia. Owing to the fact that there is no rival cultivated crop, the settler on a new plain, if not a tender of flocks, usually grows wheat year after year as long as the yield will



Note the area of wheatland abandoned and the yield in Ford County (100° W. Longitude) year by year. The high yields of 1931 kept the farmers trying during the bad years from 1932 to 1941.

A Canadian agricultural expert said to the senior author as they passed a magnificent field of wheat in Alberta, "That crop is good enough to keep that farmer broke for six years." Note carefully the wheat yields in these two counties, one being about 120 miles west of the other. In crossing this area by rail from the east, there is a quick transition from the region where there are trees around the houses and on the skyline, to one where the skyline is clean cut and the few houses are as shadeless as desert stones.

be at all profitable. Years ago Illinois and Iowa passed through this exploitation or continuous-cropping stage, which prevails at the present time in the more newly settled lands of Kansas, Nebraska, Oklahoma, and Texas. The Red River Valley of the North, comprising the major part of the wheat districts of Minnesota, North Dakota,



Grain elevator—the business end of any one of many scores of railway station settlements between the humid East and the Rocky Mountains.

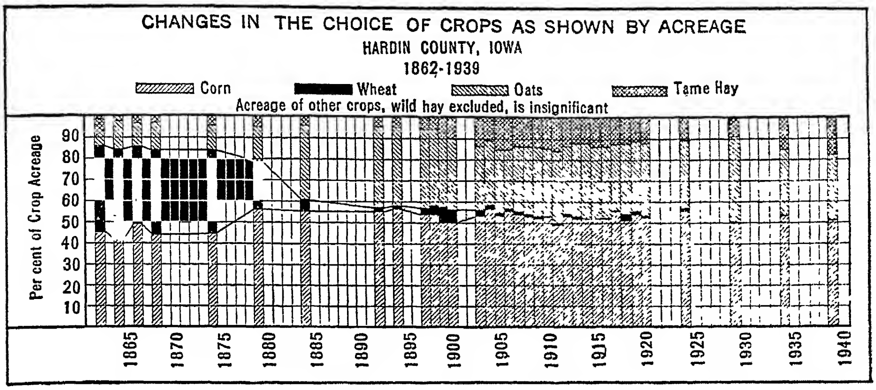
and Manitoba, has experienced a decline in yield and is now abandoning continuous wheat production in favor of crop rotation and live stock (especially dairy) farming. With the possible exception of the Russian black-earth belt, there never was in the whole world an easier place than the Red River country for the growth of wheat. This fertile plain, the bed of a glacial lake, often for miles literally as flat as a floor, without a stone or tree, lends itself perfectly to the use of the most complicated machinery and large-scale production. Year after year wheat has been grown until the declining yield has made the farmers turn to other crops—the raising of poultry, the keeping of cattle, the making of butter and cheese. The tall white silo of dairy farming is gradually displacing the big red grain elevator in many wheat-growing areas.

At the present time in western Canada, where railroads have been built across open, empty, treeless plains, the settlers are still trying to get along with continuous wheat growing which will last them one, two, or three decades before they too must take to other crops and cattle keeping. In the meantime these wheat crops on the virgin prairie soil of the harvest frontier are larger than those of the Red River Valley. It is possible that the Canadian region suitable for the extension of wheat growing reaches 60° north, and extends from Lake Winnipeg to the Rockies. Even Alaska reports good wheat yields from short-season varieties of spring wheat.[11]

The Russian peasant also exploits the soil in the same way when he emigrates to central Siberia and settles on those endless plains called steppes where the trans-Siberian railroad has brought about a remarkable development of the fertile black-earth belt and large shipments of grain from the region to urban markets.

While important for the frontiersman, wheat is also important in established crop rotations and mixed farm-

[11] Wheat production in Alaska is entirely for local use. Siberian, Reward, and Garnet wheats are grown in the Tanana Valley, where yields average 20 to 25 bushels per acre. In the Matanuska Valley Siberian and Chogut are the chief varieties, with an average yield of 22 bushels per acre.—National Resources Committee, *Regional Planning, Part VII—Alaska, Its Resources and Development,* Washington, December, 1937, pp. 115, 116, 120. And the Alaska crop continues to be insignificant for good reason—comparative cost,



The crop record of a corn belt county from early settlement to 1939. The significant thing is the disappearance of wheat, replaced by oats and hay. This is an example of, "Wheat goes west."

ing for two reasons. It affords an easy way to start pasture and hay fields, because the young grass can grow up as the wheat grows, the wheat serving as a nurse crop. Among keepers of livestock the straw is valuable for bedding for the animals. Wheat or other small grain thus becomes essential in the rotation farms of north central and northeastern United States and in the semi-garden agriculture of Belgium but not so vital as it is on the new plains of Canada and Siberia. The greater care in fertilization and labor holds the total production of wheat in densely peopled lands at a high figure.

Effect of Cheap Wheat on Farm Value in Old Countries. These new lands upon the plains of North America and other continents were opened up by railroads, and often actually given away. This made the production of wheat a much cheaper process in these lands than in Europe, where high land values and high rents are large factors in crop cost. With wheat production made easy by the new machinery, it became so cheap that, especially during the later years of the nineteenth century, it was no longer profitable to grow it on much of the land in the eastern United States and western Europe, particularly Great Britain, where it had long been the mainstay as a money crop. Animal products were cheapened by the same forces. Accordingly land values fell in both regions. Many farms have been abandoned in New England and New York, while many thousands more throughout the North Atlantic slope would sell for less than before there was a mile of railroad in America. New York state produced 12 million bushels of wheat in 1839 and 7½ millions in 1942.

6. *The Production of Wheat in Europe*

Importance of Europe. North America is such a heavy producer and exporter of wheat that it is something of a surprise when we first learn that normal, peacetime Europe, excluding Russia, produces much more wheat to the acre and more wheat altogether than

any other continent.[12] It is equally surprising to learn that Russia in recent years has been producing about as much wheat as is grown in North America and that her bumper crop of 1,464 million bushels in 1937 was 45% larger than the largest wheat crop ever grown in the United States.

Europe, excluding Russia, is only two-thirds of the size of the United States, but the former has over 400 millions of people, while the latter has less than 140 millions. In order to get enough to eat, the Europeans must till their land thoroughly. While the wheat farmers on the cheap lands of Kansas, the Argentine, or the prairie provinces of western Canada are by their extensive but inexpensive methods averaging 11 to 16 bushels per acre from land worth from $10 to $50 per acre, the careful English farmer, with a systematic crop rotation, is averaging 34 bushels or even more per acre on land worth over $200. In Holland the average yield per acre is about 44 bushels, and in Denmark it is 43 bushels, as compared with 13½ bushels in the United States. The western European tenant farmer does not make as large profits per acre as the American farmer, because he has to pay high rent and his higher yield requires much expense for labor and fertilizer.

[12] Distribution of wheat production (millions of bushels):

	1909–13 (average)	*1930–34 (average)*	*1939*
Europe *	1,348	1,516	1,695
Asia *	419 †	1,457	1,423
Russia	759	860	1,275 ‡
North America	899	1,093	1,277
World total	3,800	5,547	6,200

* Excluding Russia.
† Excluding China.
‡ Data as of 1938.

European Wheat Yields. The hills and the rain of northern and western England, Scotland, and Wales, and the rains of Ireland cause wheat growing to be of small importance in those parts of the British Isles. Most of the British wheat crop is produced in eastern England, which has the advantages of a drier climate, more fertile soil, and level land. In 1939 Great Britain harvested a wheat crop of 61 million bushels, or more than was produced by any American state except Kansas and North Dakota. In the countries of northwestern Europe the use of large amounts of fertilizer, careful seed selection, and scientific crop rotation result in exceptionally high yields per acre (see Table 23). However, the total output, in spite of high yields per acre, is inadequate to meet the needs of the large populations of these countries. Thus, industrial Belgium, with 712 persons per square mile, ranks second only to Great Britain among the world's great importers of wheat. France, with only one-sixth as much tillable land, usually has a wheat crop of over 300 million bushels, or about 40% of the amount produced in the United States. French farms average 20 acres each and those of the United States average 174 acres. Stimulated by a high tariff the French farmers generally make their country about 90% self-sufficient in wheat. Because of effective tariff protection, wheat is grown upon about one-fourth of all arable land, including much rough and poor land. As a result, the French yield of 23 bushels per acre is the lowest in western Europe, yet it

is more than double the average yield obtained in Kansas, North Dakota, Oklahoma, and Washington, our leading wheat-growing states.

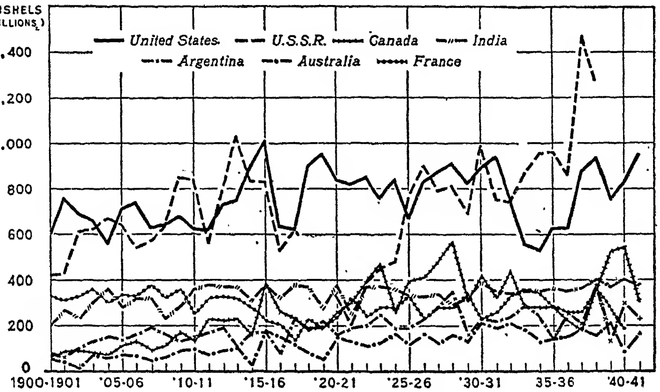
The European wheat grower, who gets high yields on his high-priced home lands with their high rental, usually adopts frontier methods if he emigrates to the plains of the United States or Argentina where land is cheap. The same process is repeated within the United States. Old states like New

TABLE 23

WHEAT TRADE AND PRODUCTION

Exporting country	*Net exports,* millions of bu.*			*Production, millions of bu.*			*Yield, bu. per acre*
	1909–13 (av.)	1930–34 (av.)	1938	1909–13 (av.)	1930–34 (av.)	1938	1930–34 (av.)
Canada	94	220	157	197	349	360	13.6
Argentina	85	144	116	147	244	379	13.8
Australia	50	128	96	91	186	155	12.2
United States	103	58	106	690	733	932	13.5
Russia	164	47	49	759	860	1,275	10.0
Hungary	42	17	28	71	77	99	19.4
Rumania	54	11	43	159	103	177	13.4
Algeria	5	10	2	35	33	35	8.4
Yugoslavia	..	5	5	..	79	111	15.6
Tunisia	0	5	4	6	13	14	6.5
Bulgaria	11	5	3	38	53	79	17.2
Poland	..	3	3	..	74	80	17.4
India	51	1	3	352	356	402	10.7
Importing country	*Net imports,* millions of bu.*			*Production, millions of bu.*			*Yield, bu. per acre*
	1909–13 (av.)	1930–34 (av.)	1938	1909–13 (av.)	1930–34 (av.)	1938	1930–34 (av.)
United Kingdom	215	220	219	59	51	73	33.6
Belgium	51	43	39	15	15	20	38.3
China	..	41	25	..	821	640	16.7
France	43	33	1	326	305	360	23.0
Brazil	20	32	40	..	6	6	14.3
Italy	53	30	14	184	253	297	20.8
Holland	22	27	29	5	12	16	44.2
Eire (Ireland)	..	19	17	.	2	7	39.5
Switzerland	17	19	17	3	5	7	31.2
Greece	7	19	14	16	18	36	11.4
Denmark	7	14	4	6	11	17	43.0
Germany	69	13	37	131	170	205	32.1

* Including flour in terms of grain.
Source: U. S. Dept. of Agriculture, *Yearbook of Agriculture* and *Agricultural Statistics* (annual).



Forty years of wheat production in leading countries, 1900 to 1941. Note the extreme fluctuations in the countries on the arid edge, especially Australia and Canada. The United States has three different regions to help hold it more steady. Russia arises as she mechanizes and gets her tractor plows into the black soil.

York, with an average yield of 21.6 bushels per acre in 1930-39, have, through good care, a higher wheat yield than the rich plains states of Kansas and North Dakota, where yields average 11.8 and 8.0 bushels respectively.

In the Mediterranean countries of Spain, Portugal, Algeria, Tunisia, Italy, and Greece, where the climate is ideal if enough rain falls, wheat is the chief grain. But the percentage of tillable land is small owing to the rough nature of the country, the yield is lower than in northwestern Europe largely because of inferior methods, and the amount produced is not sufficient for the dense population. Yet Italy, with a crop of more than 250 million bushels of wheat per year, produces 2½ times more wheat per acre than North Dakota.

European Wheat Exporters. Southeastern Europe is the only part of that continent having in normal times a wheat surplus for export. The grain-growing plains of the Danube Valley in Hungary, Yugoslavia, Rumania, and Bulgaria and of the Black Sea Basin of Russia are normally given over to the growing of wheat as the chief money crop. For decades tramp steamers have sailed out from Great Britain with coal for Italy, on to the Black Sea in ballast, and have returned laden with wheat for the countries of northwestern Europe. Each year following the wheat harvest, tramp ships flock to the ports of Varna, Constanta, Sulina, Galati Braila, Odessa, and Nikolaev to take on cargoes of wheat.

Although wheat production in Russia was greatly reduced for a few years after World War I when the great social and economic revolution was getting under way, in 1925-29 the nation's wheat output averaged 791 million bushels a year, or 32 million bushels more than the average crop of 1909-13. During the nineteen-thirties wheat production continued to expand, the harvests of 1,464 million bushels in 1937 and 1,275 million bushels in 1938 being the largest wheat crops ever grown by any nation. Individual farms in Russia have disappeared, and farming is now con-

ducted on state-operated farms where the worker is paid wages or on collective farms where they receive a share of the crop according to their work. In 1938 a total of 483,500 tractors and 153,500 combines were in operation, and mechanization has brought about a considerable increase in the efficiency of production.[13] The great centers of wheat production are in southern European Russia, winter wheat predominating in the Ukraine, while spring wheat is grown east of the Don River and in Siberia where the autumns are drier, winters are colder, and snowfall is often light.

7. *Wheat in Asia*

China. While wheat is grown from Smyrna at the west of Asia to Vladivostok at the east, the small population clustered thickly upon the oases of western Asia, Arabia, Persia, Turkestan and other arid interior countries grow only limited quantities for their own use. About three-fourths of Asia's production of wheat, which ranks second only to Europe, occurs in northern China and in northwestern India (see Fig. 403). Millions of Chinese depend upon wheat as their staple item of diet and have never seen rice. Wheat flour in China is used for unleavened biscuits, noodles, and boiled dumplings, for raised bread is seldom eaten.[14] China *may* be the world's greatest wheat producer, but we do not know, for Chinese statistics regarding agricultural production in the past have been notoriously incomplete and unreliable, and even now such data are clouded with uncertainty.[15] Although some wheat is grown in nearly all parts of China proper, little is produced south of the Yangtze Valley. Winter wheat predominates south of the Great Wall, while in the north and northwest wheat is planted in the spring. Since production is inadequate for domestic needs, China imports wheat and flour each year from Canada and the United States.

India and Japan. India in bad years eats her crop and in good years has a small export. With her uncertain climate and large population, she does not promise much wheat to feed other lands. The Indian wheat is chiefly grown in the dry Indus Valley and on the plateau near Bombay. Practically none is grown in the wet Ganges Delta or on the moist coasts of the Peninsula.

The Japanese wheat crop of about 60 million bushels a year is equal to approximately one-tenth of her rice crop or to the wheat crop of Oklahoma. Wheat is grown as a spring crop on the cooler and less densely populated island of Hokkaido, while on the crowded island of Honshu it is planted in the fall on the paddy fields after rice has been harvested or in the uplands following a crop of beans or other vegetables.

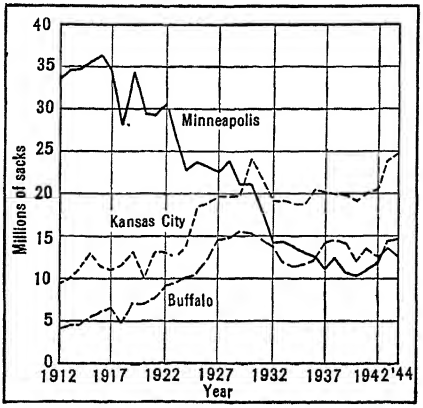
Siberia and Manchuria. There is little doubt that the great Siberian plain reaching nearly all the way from the Urals to Lake Baikal, and closely re-

[13] In 1938 yields of winter wheat were 16.3 bushels per acre and 13.2 bushels for spring wheat. —George B. Cressey, *Asia's Lands and Peoples,* McGraw-Hill Book Co., Inc., New York, 1944, p. 308.

[14] George B. Cressey, *China's Agricultural Foundations,* McGraw-Hill Book Co., New York, 1934, p. 102.

[15] Our government publishes no data on Chinese wheat production prior to 1931. Since then, the largest crop of 848 million bushels was grown in 1936.—U. S. Dept. of Agriculture, *Agricultural Statistics, 1942,* Washington, 1942, p. 16.

sembling in climate and in its rich black flatness much of the Canadian wheat country, is the most promising future wheat region of Asia. Under the Soviet regime the railroads of western and central Siberia have been improved and expanded, and agricultural progress has been most rapid. Wheat is the major item of outbound traffic from the fertile



The competition of cities in flour milling suggests that it costs less to move wheat than flour. (Data from *The Northwestern Miller Almanac.*)

steppe lands that taper eastward like the apex of a triangle toward Lake Baikal and which are wedged between cold on the north and aridity on the south.

East of Lake Baikal, Manchuria has the best grain-growing possibilities. This area resembles the Red River Valley of the north and has suitable soil and climate for the growing of wheat. Perhaps some day the potential wheat lands of Manchuria and eastern Mongolia will produce ten times the present annual crop of 30 to 40 million bushels. There is no reason for Europe to expect to consume much or any of the prospective Manchurian wheat, as the large and increasing population of eastern Asia, now importing wheat, will probably take it all.

8. *The Manufacture of Wheat Products*

Flour Milling. The manufacture of wheat products has sprung up either near the wheat fields or along the line of wheat shipment. The waterfalls at Rochester and Niagara Falls, both being close to the Erie Canal, led to the early development of milling. Then the flour mills followed the wheat fields westward. After the adoption of the gradual-reduction process, Minneapolis, located at the falls of St. Anthony on the Mississippi River and near the edge of the Spring Wheat Belt, became the world's greatest flour-milling center. This city reached its peak during World War I with an annual output of 18,000,000 barrels of flour.[16]

In 1930 Minneapolis yielded leadership in flour milling to Buffalo and was later surpassed by Kansas City.[17] Buffalo lies on the main spring-wheat route from Duluth to the sea, and its huge elevators receive about half of all grain carried down the Great Lakes each year. Cheap water transportation, the abundant hydro-electric power of Niagara Falls, and nearness to great urban markets make Buffalo the nation's leading milling center, which in 1943 was followed in importance by Kansas City, Minneapolis, Toledo, and St. Louis. Since 1925 the mills of Buffalo and Kansas City have operated at a con-

[16] Evan B. Alderfer and Herman E. Michl, *op. cit.*, p. 424.

[17] See Victor G. Pickett and R. S. Valle, *The Decline of Northwestern Flour Milling*, University of Minnesota Press, Minneapolis, 1933.

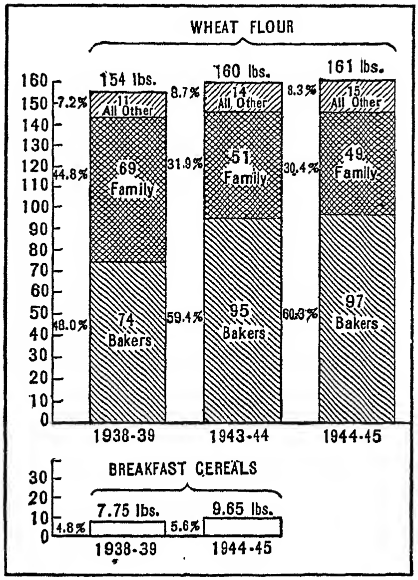
sistently higher capacity than those of Minneapolis, and many Minneapolis millers have built or bought mills in other centers.[18] Kansas, Minnesota, New York, Missouri, and Texas are now the leading flour-milling states. Since 1900 the production of spring wheat in the United States has declined while the output of winter wheat has greatly increased, a long-run trend that is reflected in the decline of Minneapolis and the rise of Kansas City, St. Louis, Wichita, Houston, Fort Worth, and other southwestern milling centers.

By-products. In various towns along the route of wheat shipment from the Mississippi Valley to the sea, as at Battle Creek, Mich., there have sprung up manufactures of prepared breakfast foods, an increasing form of cereal consumption. These, however, use other grains by themselves or in combination with wheat.

The chief by-product of the American flour mills, bran, the outer covering of wheat, is used as stock feed, especially for dairy cattle, in the same populous regions that buy the flour. Minneapolis and Buffalo, in particular, are well located in proximity to well established dairy industries. It is interesting to note that China has so few domestic animals that the flour mills of Shanghai are handicapped in the disposition of their by-products.

9. *Wheat Trade and the Future Supply*

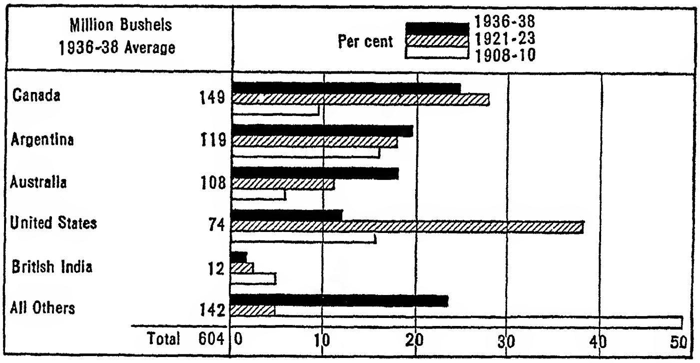
Exporting Countries. Although about 35 countries have an annual wheat crop of more than 10 million bushels each and although 11 nations produce more than 100 million bushels a year apiece, there are only 7 major exporters of wheat (see Table 23). In the years preceding World War II, Canada, Argentina, and usually Australia surpassed



Per capita consumption of grain products in the United States shows the gain by the breakfast food habit and the commercial baker. A declining proportion of young husbands will be able to tell the bride about the bread Mother used to bake.

Russia and the United States which prior to World War I were the world's leading wheat exporters. Canada (pop. 12,000,000), Argentina (pop. 14,000,000), and Australia (pop. 7,000,000) have very limited domestic markets, and each normally exports more than three-fifths of its wheat crop. These three countries are dominantly agricultural and pastoral. They have much level land, fertile soils, good but not

[18] Evan B. Alderfer and Herman E. Michl, *op. cit.*, pp. 427, 431.



Exports over this thirty-year period show the declining role of the United States and the results of European attempt at self-sufficiency.

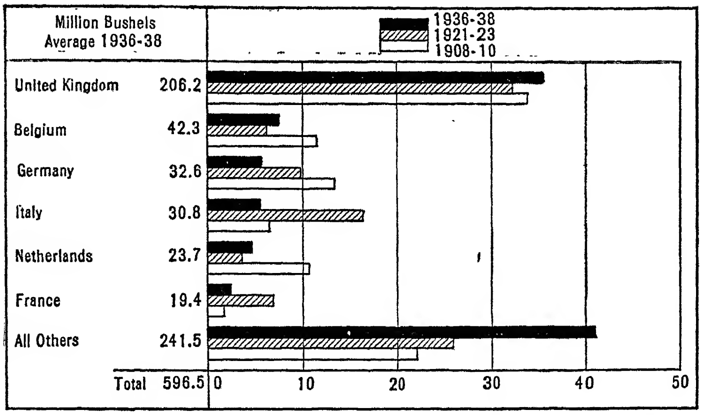
ideal wheat climates, mechanized farming methods, low wheat yields per acre but high yields per man, low costs per bushel, large crops, and large surpluses for export. They are and probably will continue to be the world's leading exporters of wheat.

In contrast, the United States has a great domestic market with over 132,000,000 people who more and more are coming to live in cities and work in factories and offices. For some years it has become apparent that an increasing portion of our wheat crop will be needed at home and that the volume of our wheat exports will decline. In 1934-38, when governmental policies of restricting production and raising prices were in vogue, our net exports reached their lowest ebb since the Civil War, averaging only 23 million bushels a year. In 1938-40 our net exports of wheat averaged about 60 million bushels a year, as compared with 103 millions in 1909-13.

While few would dare to predict just what turn the future of Russia may take, it seems likely that Russia will remain a major wheat exporter for some time to come. The sale of wheat and other commodities gives Russia the purchasing power with which to buy goods needed from abroad. However, as the movement of men from farm to city continues and as the standard of living improves, the average Russian may turn from black to white bread as millions of people in western Europe have done, and more wheat will be needed at home. In the vast domain known as the Union of Soviet Socialist Republics, embracing more than one-sixth of the world's land area, there were in 1940 more than 192,000,000 people to be fed.

Hungary and Rumania are old and distinctly agricultural countries, which lack the basic resources of coal and iron needed for a great manufacturing industry. Undoubtedly they will continue to export wheat to the densely populated and industrialized nations of western and central Europe. Their methods are unscientific especially in Rumania. This gives room to hope for more wheat when needed.

Importing Countries. Among the 12 leading wheat-importing countries, only two lie outside of Europe. China, a major producer, now ranks high as an importer (see Table 23), but it is pos-



Wheat and flour imports for three-year averages at the end of a thirty-year period show that while the continent of Europe strove for self-sufficiency, Britain continued to be unafraid and depended upon her ships and her markets.

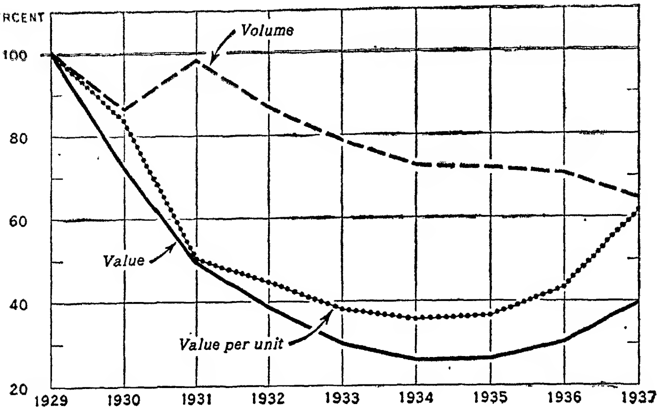
sible that she may be able to meet her needs from domestic production if political stability and better internal transportation facilities are once established. Brazil, however, is a predominantly tropical country, harvesting only about 6 million bushels of wheat a year in her southernmost state of Rio Grande do Sul, and she must continue to depend heavily upon imports.

Throughout the nineteenth and twentieth centuries Great Britain has continued to be the world's premier importer of wheat.[19] So highly developed are manufacturing, trade, and other industries that less than 7% of all workers are engaged in agriculture, and today no great nation is so dependent upon imported food. Less than 2,000,000 acres are planted in wheat each year, and Britain normally obtains two-thirds to three-fourths of its wheat supply from overseas.

The Britain of 1946-56, shorn of foreign investments and fighting hard for exports, may find it necessary to change her parklike rural landscape to one that bespeaks an earnest agriculture—companion pieces to the great houses that have become national trusts and orphanages.

In the years preceding World War II, virtually every country on the continent of Europe, spurred by frantic nationalism, produced more wheat than it did before World War I. Germany, Italy, and France, in particular, made strenuous efforts to become self-sufficient in foodstuffs regardless of the cost to the consumer. In these countries wheat production was stimulated by high tariffs, production subsidies, and by regulations compelling millers to grind a certain percentage of domestic wheat for every barrel of flour, while wheat imports were subject to rigid governmen-

[19] It is often said that the world wheat price is determined in Liverpool, for here is to be found the greatest single focus of supply and demand. Traders on the wheat market are constantly speculating on the future conditions of supply and demand. These men may be said to have economic geography as their business.



Starting with 1929 as 100%, the volume and gold value of the world exports of wheat explain much international consternation. The declining volume is due largely to European attempts at self-sufficiency, and paralyzing decline in price started the great exporters in attempts to agree on reducing exports, an agreement that could never be reached. At home it was different. In the United States, we paid the farmers money to reduce production.

tal control.[20] As a consequence, German, Italian, and French wheat imports dropped far below the levels prevailing prior to World War I. Most of the smaller nations pursued similar policies in stimulating domestic production but with less effect upon imports. Such policies were only a part of the economic nationalism that engulfed so many nations and which most certainly helped to bring about the most devastating war in human history. The effect of these policies upon wheat trade is shown by the fact that in 1934-38 Great Britain alone imported more wheat than did all of the countries in continental Europe. In spite of the dislocations in the wheat trade prior to and during World War II, Great Britain and the countries of western Europe will continue as the market for the great bulk of the world's wheat exports.

There was much talk in 1945 of a possible rising standard of living. For much more than half of the human race, that means more wheat.

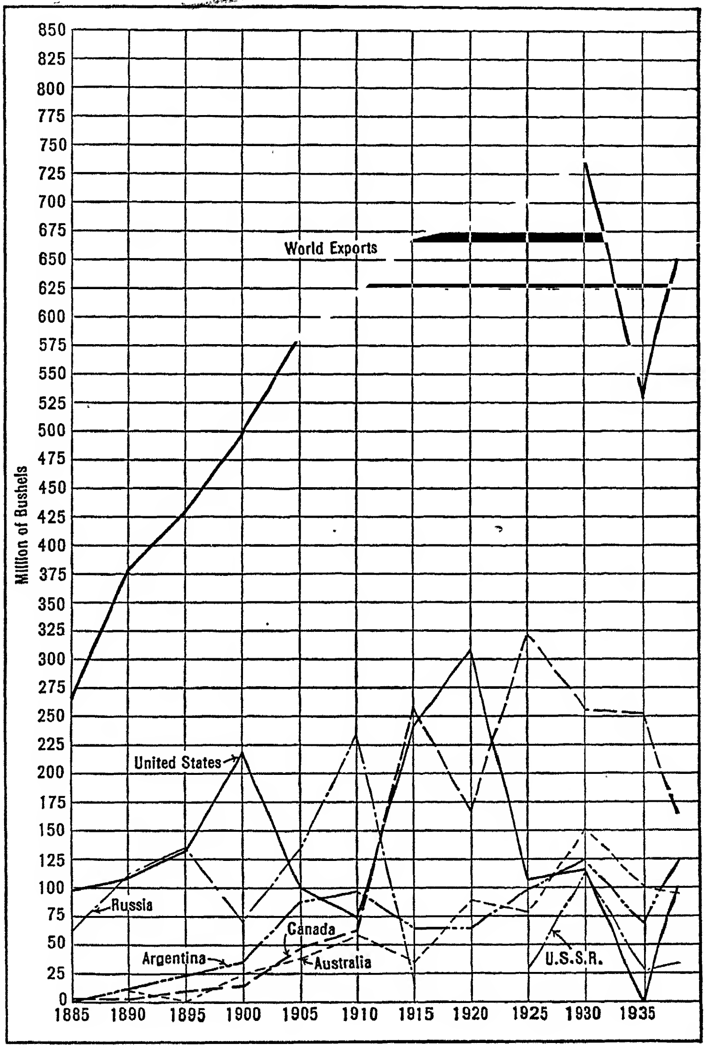
The Future. In a careful analysis of the world's potential wheat supply,[21] Dr. O. E. Baker of the United States Department of Agriculture found that unfavorable temperature, moisture, land surface (topographic), and soil conditions prevent the production of wheat on 46,500,000 square miles, or about 90% of the world's land area. He ascertained that approximately 5,500,000 square miles are potentially available for the growth of wheat. Since corn, oats, hay, vegetables, and other crops will compete for much of the land suitable for wheat, Dr. Baker concluded that it appears unlikely that over 3% of the

[20] In 1933-34 wheat in Berlin, Milan, and Paris sold for almost three times as much as it did in Liverpool.—See Henry C. Taylor and Anne D. Taylor, *World Trade in Agricultural Products,* The Macmillan Co., New York, 1943, p. 114.

[21] O. E. Baker, "The Potential Supply of Wheat," *Econ. Geog.,* vol. 1, March, 1925, pp. 15-52.

world's total land area will ever be devoted to wheat production. It is estimated that in 1939, and again in 1940, wheat occupied approximately 633,000 square miles, or only about 11% of the land that is potentially suitable for wheat.

It should be borne in mind that the natural or physical limits to wheat production are not inflexible, for man constantly is overcoming the obstacles of nature. Thus, new short-season varieties enable man to push back the wheat frontiers into the colder lands of the



Fifty years of world exports of wheat and flour in millions of bushels, total and by countries. Note especially the figures for the United States, Canada, Argentina and the disappearance of Russian exports for a decade because of political conditions.

earth. Drought-resistant varieties, dry-farming methods,[22] and irrigation projects help to overcome the shortage of moisture in dry lands, while in wet lands excessive moisture is reduced by drainage. Terraces are used, as in the Orient, to create level land on hillsides. Naturally poor or worn-out soils are often made productive through the use of fertilizer and scientific crop rotation. It is clear, therefore, that the land potentially available for wheat is not a fixed entity. It is equally clear that there will be ample land for wheat production for a long time to come.

10. The Importance and Use of Rice

The World's Chief Food. The old adage that bread is the staff of life is a striking example of the ease with which a half-truth is perpetuated as a universal verity. The fact is that hundreds of millions of healthy and industrious men have never seen bread as we in the Occident know it, but that is no sign that these men are savage, barbarian, or heathen. Throughout the Orient from India to Japan, teeming millions obtain their carbohydrate from rice, which is low in gluten and will not make light bread. Among the world's great foodstuffs, rice ranks first.

Although rye, corn (maize), certain millets, and grain sorghums in some areas are dominant foods and are even preferred to other grains, only wheat ranks with rice in food use. Approximately four out of five of the world's inhabitants prefer and consume predominantly rice or wheat,[23] and many of the remainder would change to wheat or rice if they had the easy possibility to do so. The wheat-eating populations are more prosperous and enjoy a more diversified diet than do those whose principal food is rice, and the number of people who obtain 60% or more of their food calories from wheat are greatly outnumbered by those who are similarly dependent upon rice. Although the world's wheat acreage is more than double the acreage in rice, the number of bushels of wheat produced each year is surpassed by the output of rice. In volume of production and as a staple item of diet, no grain is so important as rice.[24]

The Antiquity and Uses of Rice. The use of rice in the old lands of the East goes back into the unknown past. Centuries ago rice spread from China and India to Egypt, and North Africa, then in 1468 to Pisa in Europe, and in 1694 the governor of South Carolina succeeded in cultivating it in his garden and thus started the industry in this country. A little rice is grown throughout nearly all tropical America, on both coasts of equatorial Africa and in the Congo forests, but no people depends

[22] The object of dry farming is to retard the rate of evaporation and conserve the moisture in the soil. In occasional years the land is left fallow but is kept clean of weeds so as to build up the supply of soil water. Plowing the land after harvest slows up the capillary action of soil water, increases the absorption of fall and winter rains, and helps to retard the drifting of snow which might leave bare spots with little moisture. Sowing seeds thinly and deep planting also helps to prevent overtaxing the limited supply of soil water.

[23] See Vernon D. Wickizer and Merrill K. Bennett, *The Rice Economy of Monsoon Asia,* Food Research Institute, Stanford University, Calif., 1941, pp. 2-4, and M. K. Bennett, "International Contrasts in Food Consumption," *Geographical Review,* vol. 31, July, 1941, pp. 365-376.

[24] Estimated annual world production (1938-41) of principal grains, in billions of bushels: rice—7.2, wheat—6, corn—5, oats—4.5, barley—2.5, rye—1.5.—See U. S. Dept. of Agriculture, *op. cit.,* pp. 15, 35, 43, 57, 73, 85.

upon it so fully as do those of southern and eastern Asia, with whom its use generally replaces that of wheat, potatoes, and, to some extent, meat also. The people of Europe and America use rice as an ordinary vegetable, as well as for pudding, and in place of the potato when that crop fails. Among these western peoples, rice is more of a substitute food than a regular staple of diet. Rice is widely used as a staple article of diet in the tropics, especially tropic America. Along with beans it is the great mainstay of Puerto Rico, although almost none of it is grown there. It is much easier to boil rice than it is to bake bread. This, in combination with its good keeping qualities, may explain its predominance.

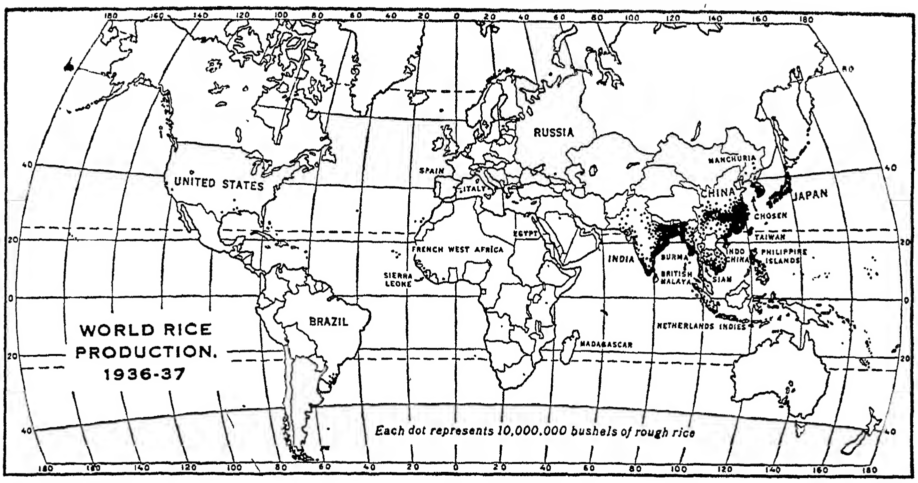
Since rice does not make light bread because it lacks the gluten, the Oriental boils the grain and eats it in that form. He flavors it with a bit of meat or fish if he can afford it; or uses curry, a hot seasoning preparation made in endless varieties. With peas and beans and some greens, rice furnishes almost the entire nourishment for hundreds of millions of people. Peas and beans are widely grown by almost all Eastern peoples who raise rice, and they are the substitute for meat, milk, and cheese of the West, while the starch of rice is the substitute for bread, potatoes, and many puddings as well. The unpolished rice eaten by the Oriental is much more wholesome than the shiny, white grain which we of the West insist upon eating. The process of polishing it takes off the most nourishing part, as well as the life-giving vitamins.[25] Polishing rice is one of the numerous cases in which appearance makes the purchaser select the really inferior article. The rice bran is a valuable cattle food and is exported as far as Europe. The straw is used for many purposes, including fodder for animals and for the manufacture of brooms, paper, matting, sandals, hats, and many other commercial and household articles used by the Orientals.

11. *The Rice Environment*

Climate, Surface, and Soil. Among the environmental factors affecting rice production, water supply is most important, for the great bulk of all rice is grown under irrigation, the rice fields being submerged under approximately 6 inches of fresh, slowly moving water for at least 75 days. While the amount of water needed in a given area varies with such factors as rate of evaporation, relative humidity, and soil conditions, a total of 45 to 65 inches of water is generally required for rice production. If the rainfall is abundant and relative humidity is high, less water is needed from streams and other sources.[26] Furthermore, rice requires a mean temperature of more than 70° F. During the growing season of 4 to 6 months. Hence, rice is a product of the tropics

[25] Calories do not tell the complete story of nutrition. They must be made alive with vitamins found in living food such as uncooked greens, most husks, such as bran, the outer coating of rice, milk and its uncooked derivatives, orange juice and all fruits. Hence the practice of giving orange juice to the baby that is fed upon dead (pasteurized or condensed) milk.

[26] One finds irrigation companies in Louisiana, one of the wettest spots in the United States. Rainfall during the growing season amounts to about 20 inches, and man must provide an additional 25 to 30 inches of water, which is diverted from streams and wells onto the rice land. Rice does not require high humidity, for it thrives in the dry summer heat of the Nile, Po, and Sacramento valleys.



The map of world rice production shows that although we have now mechanized our rice technique, the United States has scarcely yet obtained the position of an "Also Ran." Notice southern Brazil. The monsoon and the rice paddy, the flooded paddy, still dominate and promise to continue to do so. There is no soil destruction in that agriculture.

and sub-tropics, most of it being grown in regions of reeking humidity with frequent, almost daily rains. In such a climate all the European grains—wheat, barley, rye, oats, and buckwheat—fail miserably, and corn is far from its best, owing to the bad effects of the moisture. Rice is to the regions with moist summers what wheat is to the regions with a dry summer. The two plants do not thrive in the same region unless, as is the case in a few districts of China and Japan, a crop of winter wheat can be harvested before the beginning of summer rains, which furnish the proper conditions for rice.

Level land is obviously essential for irrigation, and where it is lacking man must create it artificially as he has done by laboriously building terraces on the steep hillsides in many parts of Japan, China, the Philippines, and the East Indies. Although rice is grown on a variety of soils, there must be an impervious sub-soil to prevent the loss of valuable irrigation water by seepage. Ideal soil conditions are found on many an alluvial plain, where a top-soil of fertile and friable silt has been deposited above a layer of impervious clay.

Although rice is now produced in the tropic and sub-tropic lands of every continent, 95% of the world's crop is grown each year in southern and eastern Asia.

Rice and the Monsoon. In the summer season the Asiatic monsoon, a seasonal wind, a gigantic sea breeze, blows inland from the warm, moist Indian and Pacific oceans across all coast lands between latitude 22° near Bombay and latitude 45° north in Japan. It gives to southern and eastern India, Ceylon, Burma, Siam, and Cochin-China, the Philippines, China, southern Korea, Japan, and the windward side of many East Indian islands a heavy, warm midsummer rain.

The Asiatic summer rain produced by the monsoon is one of the greatest factors in the relation of man to the

earth. Southeastern Asia and adjoining islands, the region of monsoon climate with rice the leading cereal, is the home of more than half the human race. One of the important reasons why this small fraction of the world holds so many of its people is because the monsoon climate has rain at the season of greatest heat and growth rather than in the cooler period of least growth such as results from the winter rainfalls of California, Spain, Italy, Australia, and Chile. The climate possesses first the intermittency to compel people to work for the non-productive season of drought and then rainfall enough to permit great production and thus great food supply and its resulting numbers. The rainfall is regular over large areas—a factor of inestimable importance.

Rice flourishes in the wet summer due to the monsoon, and in these parts of southeastern Asia, where the moisture is sufficient to its satisfactory growth, rice is the mainstay of the population. Rice is the grain of the moist low plain, and contrary to the general opinion it is a luxury to millions of poorer Chinese and Japanese who live on the cheaper and less desirable millet, European small grains, corn, sweet potatoes, and other cereals not known in America.

These European and other grains are raised where rice is impossible of cultivation. Thus, in northwest India the valley of the Indus does not have much rain and is an important wheat grower, as are the central plateaus of India around Bombay and upper Bengal. In north central and northern China, also, rice does not thrive, and wheat is extensively grown. In colder or more arid localities comes barley, and in the region of Peiping and southern Manchuria, kaoliang (a sorghum) and maize, while many districts of central and north China have millet as their chief cereal. Southern Korea depends much upon rice, while in the rougher and colder north they grow barley, rye and oats, millet, and some wheat, and the same practices prevail in Japan.

Wheat and barley are often grown on rice land in winter, and the two grain crops per year measure the intensity of production. To get the two crops in one year requires the laborious time-saving device of transplanting the rice *by hand* from seed bed to field. This practice saves weeks and makes possible the *two* crops on the same land.

12. The Production of Upland and Lowland Rice

Upland Rice. The thousands of varieties of rice due to the age-long cultivation are divided into two classes, known respectively as upland rice and lowland rice. Lowland rice must be grown in water, while the upland rice is grown much like wheat or oats and is grown chiefly where population is sparse, land is abundant, and rain is heavy.

In those parts of the wet tropics such as Sumatra, Borneo, the Malay Peninsula, or some parts of Burma and Indo-China, Equatorial Africa, the Dominican Republic, and many other parts of tropic America where the tropical jungle covers with its dense tangle every foot of the land except where man has fought it back, upland rice is grown in a shiftless manner such as commonly prevails wherever a sparse population uses abundant land.

When a new rice field is wanted, the

dwellers in the thatch huts will begin the year by cutting down the forest. Among stumps and prostrate logs, the upland rice is planted in holes made with a sharp stick and filled by the bare foot. As young rice is much prized by wild animals, from the elephant down to the small rodents, the clearing must be watched until the harvest. After two crops are taken, the field is abandoned for a fresh field and the tangled jungle promptly reclaims the land. This is the age-old primitive agriculture.

Upland rice sometimes is grown with greater care on land that cannot be irrigated in a region where all land suitable for lowland rice has been appropriated, as in Japan. As a general rule, however, methods of upland-rice culture are primitive and careless, and the yields are uncertain and low. In the aggregate, upland rice accounts for a very small portion of the world's total rice supply.[27]

Lowland Rice in Densely Peopled Lands. Most of the countries with monsoon climates are too densely peopled to grow their rice in this crude way. In such localities the land once cleared is kept in cultivation for centuries. Such dense populations nearly always grow the wet variety of rice, because of its greater and more certain yield. Few crops are surer than irrigated rice, and few more uncertain than upland rice, which likes a half inch of rain per day to do its best. Lowland rice must be grown by irrigation, and the devices used in fitting and keeping the land for this service are among the greatest monuments of human diligence in the world. They are certainly the most creditable constructions produced by tropical peoples, the only rivals being the slave-built monuments of tyrants. In Ceylon, for example, the railway that goes from the seacoast to the highlands goes through an irrigated plain divided by low banks into ponds of small area, —rice fields, each of which has by great labor been leveled so that the water may be of uniform and proper depth for rice growing. As the railroad climbs the slopes of the hills the rice patches continue, with smaller area and higher banks, turning at last into a giant flight of gentle water steps, one of the most beautiful landscapes that the world possesses. Many mountains in Java are similarly terraced for rice far up their sides; and, in China and Japan, similar stupendous works have been constructed for the support of the populations, which, like those of Java and of Ceylon, are very dense and mainly dependent upon agriculture in which rice is the staple food crop. In Japan 75% of the arable land is in these irrigated paddy fields. The similar work of the Philippine Igorotes, whose steep terraces have stood for centuries, and who have themselves stood for centuries, and whom we have called savages, should make us wonder what they would call us if they saw the gullied ruins of American corn and cotton fields.

The common treatment of the lowland rice is alternately to flood it and draw off the water during the early periods of its growth. It is kept under

[27] Among the countries reporting information on upland rice, the proportion of the total rice area occupied by upland rice varies from 2% in Korea to about 10% in Java and Madura, while the proportion of upland rice to total rice production is even smaller owing to the low yields obtained from upland rice culture.—Vernon D. Wickizer and Merrill K. Bennett, *op. cit.*, footnote 6, p. 11.

These terraced rice fields made by the Ifugaos tribe in the mountains of Luzon are one of the most astonishing monuments of careful human labor. These steps with their annual rice crops have been on these mountainsides for several centuries.

Some Americans whose farms have been allowed to wash away in a single generation call these Filipinos "savages." Savagery exists in several areas—one is agricultural savagery. In that field the Ifugaos are highly civilized and those who let their farms wash away—? Land ownership in the United States is still a license to kill.

water during a larger part of its development, the water being entirely drawn off as it ripens. The water must not become stagnant, and to keep it in motion it is the common practice on the hillsides to lead a stream to the top terrace, and let the water pass from terrace to terrace down the slopes. In many places, especially in China where the water supply is often inadequate, it is necessary to lift the water from the lower terrace to the higher ones by some artificial means. Sometimes where the water is abundant, a high water wheel is used. As it revolves, the bamboo buckets, mere joints of bamboo on its run, empty water in a trough when they reach the top of the wheel. It is an exceptional place where there is sufficient water to use this water-power method. In many parts of China and India two men may be seen straddling a little dyke that separates two terraces. With a bucket they dip the water from the lower to the upper, where they pour it out upon mats so that it may not injure the little rice plants beneath. This is only one of many Oriental methods of lifting water by human muscle.

The utilization of these terraced hillsides with the accompanying menace of an avalanche of mud and water is as great a monument to the diligence and patient care of these peoples as is the construction of the terraces. Only constant vigilance prevents the breaking of the upper terraces, which, should they give way, would promptly discharge the water into the ones below, fill them to overflowing, and so, gathering force as it went down the hillside, the water would, like an avalanche, leave ruin behind it.

Labor Requirements of Lowland Rice. The labor of rice growing often involves the raising of plants in small seed beds and transplanting them in little bunches to the rice field itself. This

work, as most of the other work in connection with terrace-grown rice, can be done only by hand. The small fields make it impossible to use such machinery as reapers and at times even the ox and water buffalo. But beasts of burden are often unattainable in a densely populated country like China or Japan. There is not land enough to raise food for many animals, so the hoe in the hand of a man replaces the plow drawn by a beast, and the garden replaces the field of more sparsely peopled lands. Parts of China and Japan and India have reached the ultimate stage of agriculture, where man grows by his own labor the food for his support, and there is small possibility for increase of food production. This omission of animals is by no means universally true, for there are millions of water buffaloes plowing rice fields in the Philippines and the mainland of southeastern Asia; and India, peopled largely by people who eat no meat, has more cattle than the United States, but their chief purpose is to serve as beasts of burden.[28]

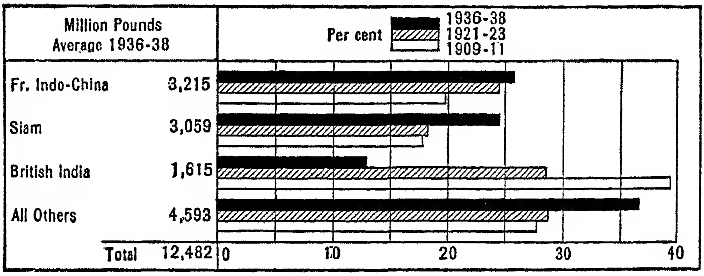
When the Asiatic rice field is finally drained, the ripened grain is usually cut by hand, tied up in bundles, and allowed to dry. To accomplish this in moist places, it is often necessary to put the sheaves upon bamboo frames. It is usually threshed by hand with the aid of some very simple devices. One of these is a board with a slit in it. Drawing the rice through the slit pulls the grains from the heads and allows them to fall into a receptacle. The grain at this stage is called paddy because of a close-fitting husk not unlike that which protects the oat kernel. As with oats, these husks cause the grain to keep much better than when the husk is removed and the final husking of rice for home use is usually deferred until the time of use approaches. Among the Oriental people the husking of the paddy to prepare it for food is a daily occurrence, commonly done by hand. One of the commonest sounds throughout the East from Bombay to Manila and from the equator to Pekin, is the pounding of a heavy mallet or pestle as it falls into a vessel full of paddy in the process of pounding the grain and loosening the husk.

13. Rice Trade and the Spread of Rice Production

Exporters and Importers. The enormous home consumption of rice in Japan, China, India, Ceylon, Java, and the Philippines make these countries

[28] We have here some of the conditions that enable us to appreciate the great differences in man's relation to the land in the East and the West, in the sparsely and the densely peopled country. The American farmer grows corn and feeds it to cattle and then eats the cattle, but one ox eats as much as five men and requires five times as much land for his support, so the numerous Orientals often omit the animal-feeding stage and grow rice and vegetables and eat them rather than feeding them to animals. Great increase in population could result from the essentially vegetable diet and the omission of animal raising. The ox that consumes as much as five men lives at least two years and will not produce over 750 pounds of meat. It is reported that the excessive amount of 5 pounds of meat per day is allowed the Argentine cowboy. Thus an ox represents 150 days' rations for the Argentinian *vs.* 3,650 days' rations (ten years) for the Oriental—one of the many striking results produced by difference in density of population.

The more closely we study geography and seek the *explanations* of human history, the more we are likely to appreciate the potency of the ratio of population to resources as a causal factor. Land hunger is a natural condition for the inhabitant of the crowded Orient. It is a problem that must be dealt with if the world is to have an era of peace—otherwise your children or grandchildren may perish by the bomb.



World's rice export, three-year averages for a thirty-year period, carries a sign of trouble; the decline of the export of British India comes during the same period her own population has increased by tens of millions and famines are therefore due.

great importers of rice.[29] The chief surplus for export to the world's market comes from the less densely peopled section of the Orient, particularly from the valleys of the Irrawaddy River in Burma, the Menam River in Siam, and the Mekong River in French Indo-China. These stretches of fertile, river-borne soil lie favorably for cultivation by irrigation. In Burma and Siam and Cochin-China, these stretches contain the larger part of the population of these countries, but the soil is so productive that large quantities of rice are left as the money crop of the natives. This surplus they carry in their native boats down through the winding waterways to Bangkok, Rangoon, and Saigon. Here, in the mills of English, German, French, and Chinese firms, the paddy is cleaned in the wasteful fashion demanded by Caucasian consumers, who eat a part of the grain which is less nutritious than the part consigned to the animals that get the rice bran.

The Spread of Rice Growing. Thus far the development of rice growing outside the Orient has been surprisingly slow and small. The annual overflow of the Nile due to seasonal rains in central Africa, and the easy irrigation, make rice as much at home in Egypt as it is in the garden farms of Japan, the lower valley of the Yangtze, or the terraces of Ceylon and Java. Some rice is grown in Egypt, but not enough for the population, probably because of the European dominance of the Egyptian agriculture. Although rice is a common article of diet in every country of America and Europe and of nearly every European colony, these many lands are usually importers, with the exception of the United States, Brazil, British Guiana, Italy, and Spain.

Rice Growing by Asiatic Emigrants. The spread of East Indian laborers to the islands of Mauritius, Reunion, and Madagascar in the Indian Ocean has introduced rice growing there, while similar people, taken to the British col-

[29] Since Korea and Formosa were a part of the Japanese Empire prior to World War II, shipments from these colonies to Japan were not classified as imports. If these shipments are counted as imports, Japan's average annual imports of 4.1 billion pounds in 1934-38 amounted to about one-fourth of the world's total rice imports. Prior to April, 1937, the foreign trade of Burma was included with British India. In 1939 the net imports of rice into British India amounted to 4.3 billion pounds.—*Cf.* Henry C. Taylor and Anne D. Taylor, *op. cit.*, p. 135, and U. S. Dept. of Agriculture, *op. cit.*, p. 50.

onies of Jamaica, Trinidad, Honduras, and Guiana, have carried with them the methods which their rice-growing ancestors have practiced for a hundred generations. British Guiana is an interesting example of these tropic American rice fields. Here, although the country is mostly uninhabited forest, there are large stretches where the level, alluvial swamp along the seashore has been utilized by the building of dykes, after the manner employed in Holland. The reclaimed land greatly resembles the rice-growing deltas of the rivers of southern Asia, and between 1898 and 1940 the acreage increased from 6,000 to 72,000. The Guiana rice crop is, however, less than one-twentieth of that of Brazil, which is now raising more rice than the United States and is exporting about 5% of it.

It is easy to let the facts of export cause unsound inferences as to total production. There is no necessary connection between the two. A small population, and a production small in comparison to other countries, permits countries like Argentina and Canada to appear large in wheat export, as French Indo-China and Siam do in rice export, yet they produced about 250 million bushels of rice each in 1939-40 in comparison to 627 millions in Japan proper, 1,896 millions in India, and 2,602 millions in China.

Rice Growing in Europe. Rice is of great value to dense populations because of the high average yield. In Japan in 1939 rice averaged 81.2 bushels to the acre, while wheat yielded 33.4 bushels. In the United States (in 1939) wheat made 14.1 and rice 51.7 bushels per acre. For this reason the cultivation of rice has been taken up in southern Europe in most places where the water supply is sufficient for irrigation. In the Po Valley of Italy a third of a million acres, equal in size to a typical American county, are carefully tilled in rice, and Italy, producing about four-fifths as much as the United States, has a large surplus for export. Spain grows about one-third as much as Italy, and Portugal and Bulgaria grow a little.

14. Mechanized Rice Production in the United States

Rice and Slavery. After the surprising success of the governor of South Carolina in raising a patch of rice in his garden in 1694, rice growing became an industry in that colony and in Georgia, since swamps along the seacoast and rivers could readily be dyked off and cultivated by Negro slaves in the Oriental way. This was the chief place in the whole thirteen colonies where Negro slaves were profitable in 1787, and it was due to the influence of Georgia and Carolina rice growers that slavery received its recognition in the Constitution of the United States. Following the abolition of slavery, the rice industry declined, and today no rice is grown in this region.

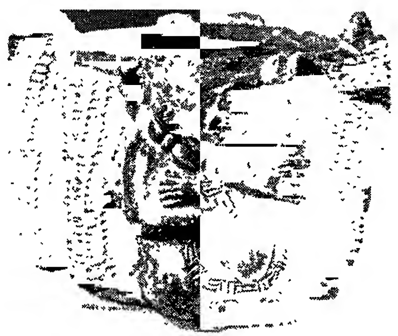
Rice in the Machine Age. The newest and most interesting of all the world's large rice fields is upon the plains near the Gulf coast in southwestern Louisiana and southeastern Texas. Here are lands of wonderful levelness and with a very satisfactory clay subsoil to keep water from soaking through. In most of this area powerful pumps are employed to lift water from streams into irrigation canals, although in some places the water of artesian wells is used. The

. . . 15

Corn, Rye, Oats, and Other Cereals

1. Corn (Maize)

The Development of Corn by the Indians. Among the major events in the world's food history was the white man's discovery of corn, or maize, which had long been the great food crop of ancient Maya, Aztec, and Inca, and of many less civilized Indian tribes throughout the New World. Corn was first brought to the attention of Christopher Columbus on November 5, 1492, and the great discoverer found it to be a common crop in the West Indies. Prehistoric graves in the New World indicate that there has been little change in the cereal over many centuries. From graves in Peru and Bolivia have come wonderfully preserved ears which show no characteristic not found in present types and some of which might even be classed as belonging to present-day Peruvian or Bolivian varieties. In Utah the graves of the Basket-Maker Indians, the earliest known inhabitants of our Southwest, have yielded ears of corn very similar to those grown by the present Indians in the same territory. A botanist at the Texas Agricultural College has investigated the genetics of maize so thoroughly that he was called to Harvard as a result. He says the breeding of the corn plant in Peru required from 10,000 to 25,000 years.



This earthenware urn of Maya creation in pre-Columbian times shows that the people of Yucatan had corn strikingly like that which we grow today. The prevailing theory of corn origin is that it came from Peru and worked its way slowly northward.

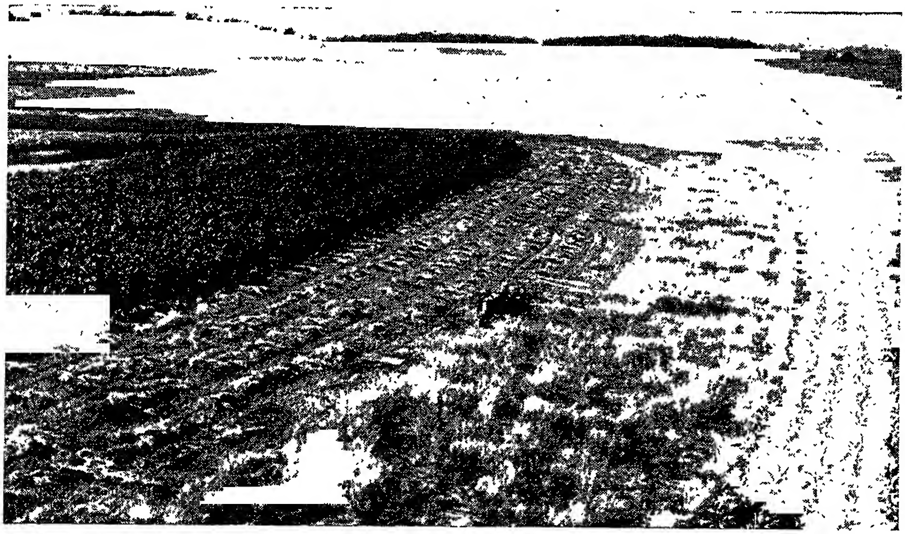
If you have done wrong to a man, you have an impulse to do it again to prove to yourself that you were right the first time. Having stolen the best of continents from the Indian, we have great difficulty in doing him justice or appreciating his achievements. In corn, Mr. Melvin R. Gilmore, of the Heye Foundation, New York, says that the Indian had under cultivation, when the white man came, the five different types of corn each subdivided into many varieties and growing far beyond what we consider Corn Belt. Mr. Gilmore laments that the white man was not intelligent enough to begin where the Indian left off. Instead, we took Atlantic Coast corn west, and then wondered what was the matter—and called the Indian a savage.

The Value of Corn to the Settlers of America. When the first English settlers landed in Massachusetts and Virginia,

A

Corn is a deadly enemy to the future of civilization because of the soil destruction that so often accompanies the growth of this clean-tilled row crop. This is Illinois, in the background, a completely ruined hill—the work of man-induced gullies—in the foreground, a very poor crop of corn—100 feet further down the slope it produced 60 bushels to the acre.

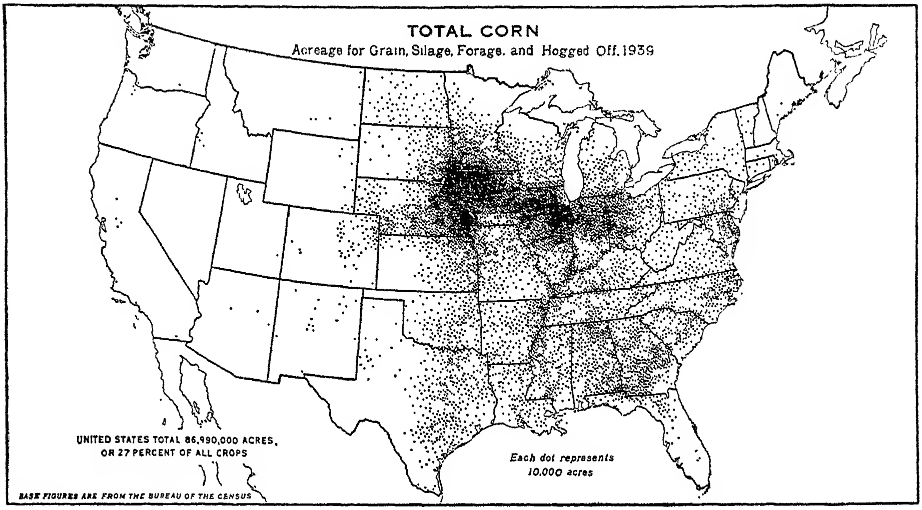
Mexico, where corn is so vital, has cornfields washed away down to bed rock.



B

By strip-cropping this Iowa farmer hopes to leave his land for future generations. Before water can get momentum in the corn strip, it runs out into the oat strip, where it will spread and have a chance to sink or run slowly through the oat plants without eroding. In some areas these strips run through several properties, and the water stands between the corn rows because they are on the level, slope just enough for slow flowing. In such cases, it takes an inch of rain to start running out and down the prepared drains which are grassed and do not erode.

The creation of the United States Soil Conservation Service is probably the most important thing in domestic policy that was done by the Franklin D. Roosevelt administration.



Corn acreage, United States, 1939. The crop was probably as important to the people of Southern Appalachia as to those of the Corn Belt proper, but it was little patches of corn grown by poor people, who are living on a basis of small commercial exchange. The man who grows corn to sell and buy gas and machinery needs more than the one-horse farmer who grows it to eat and feed the horse, the cow, and the porkers for his own curing.

the Indians presented them with ears of this valuable grain which the settlers called Indian corn, corn being the English word for grain. The colonists, to their great benefit, at once began to cultivate it, because it was so much easier for them to grow than the wheat, barley, rye, and oats with which they had been acquainted at home. These small grains, grass-like in their early growth, require for their satisfactory cultivation smooth land free from stumps and stones. This the new settler in the woods did not have. But the Indian showed him how to kill the trees by girdling, or removing a ring of bark from around the trunk, so that he could immediately plant corn among the standing trunks and, with a little rough cultivation, have unripe corn ears for roasting as early as August—a much quicker return for his labor than wheat could possibly bestow. By September or October the settler would have ripe grain that would stand a month or two awaiting his convenience to harvest it. In this respect it was superior to the small grains which must be harvested at once, lest storms beat them down. The ripe corn, moreover, yielded twice as much as the small grain, was easily kept, and could be served as food in many forms—as parched corn, the hunter's standby, made by heating the whole grain in a frying pan or over an open fire; as hominy, which is the cracked corn thoroughly boiled; as mush (samp), made by boiling the meal; or, finally, as cornbread. The husk that protected the grain served in the mattress for the colonist's bed; the stalks and leaves fed the horses and cows through the winter, even after they had served for months as a thatch for the temporary shed that shielded the animals from storm.

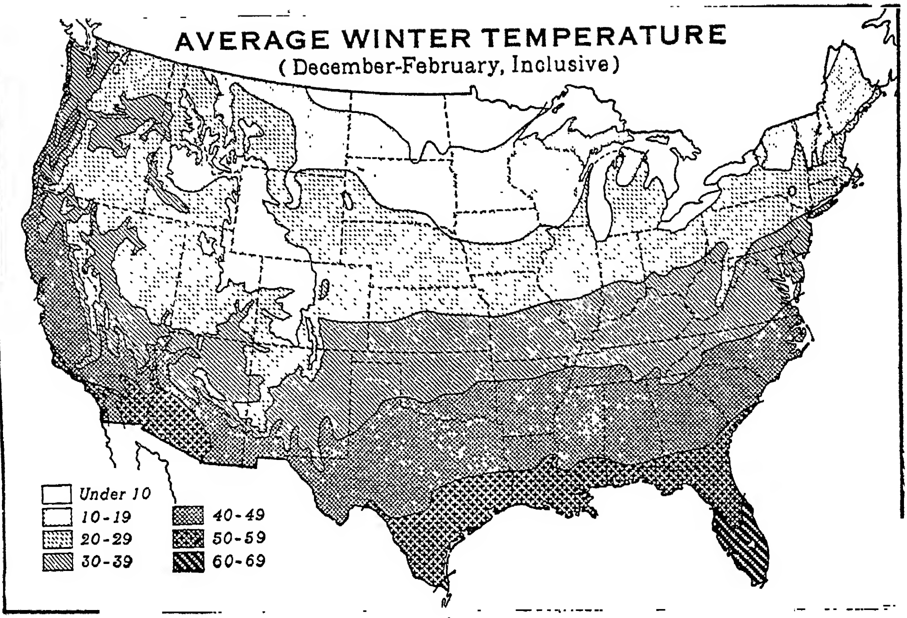
Usefulness of Corn in Rough Countries like Appalachia. Owing to the ability of corn to grow on very rough land where the other grains will not do so well, or yield so much, it has come in many parts of the world to be the mainstay of primitive or isolated hill peoples where the climate permits. In the central Appalachian Plateau of east Kentucky, east Tennessee, and West Virginia, for example, there are considerable areas, almost devoid of railroads and good wagon roads, where the primitive conditions of the Revolutionary period continue and where corn is the staple item of diet and "corn likker" provides, often, the only cash income for the poor mountaineers.[1]

As a result of the remarkable development of corn by the Indians more than 4½ centuries ago and the discoveries of modern plant breeders, man has available today a great diversity of types of corn permitting production under widely different environmental conditions. Thus, some dwarf varieties grow less than 2 feet tall and mature in 60 to 70 days, while others achieve a height of more than 20 feet and require 10 to 11 months to reach maturity. Corn is now produced from 58° N. Lat. in Canada and Russia to latitude 40° in the Southern Hemisphere. It is grown below sea level on the plains near the Caspian Sea and at elevations of over 12,000 feet in the Peruvian Andes. Drought-resistant varieties are grown by the Hopi, Zuñi, and Navajo Indians in the semi-arid sections of Arizona and New Mexico, and corn is also grown in tropical Hindustan, which has more than 200 inches of rainfall a year. No cereal is cultivated under such diverse climatic conditions, none is distributed so widely throughout the world, and only wheat occupies a larger acreage.[2]

In those regions that produce most of the world's supply, corn is a warm-weather plant requiring high temperatures both day and night during the growing season. Virtually no corn is grown where the average summer temperature is less than 66° F., or where the average night temperature falls below 55°. Corn production, therefore, is unimportant at high elevations, as in our western states of Colorado and Nevada where the days are hot but the nights are cool. It is also unimportant in regions with a cool summer, such as England, Scotland, Ireland, in fact all north Europe, most of New England north of latitude 44°, and Canada, excepting a part of Ontario. In North Dakota, the corn crop approaches the Canadian boundary. The American Corn Belt, the world's greatest corn producing region, has an average summer temperature of 70° to 80°, an average night temperature exceeding 58°,

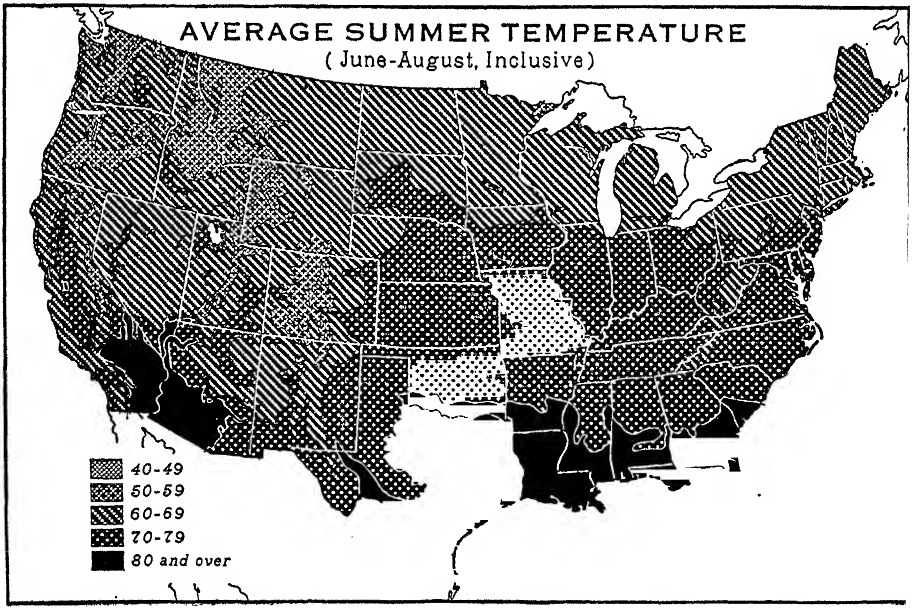
[1] This locality with its inferior corn crop furnishes a good example of the influence of environment on history. About the only way in which corn could be exported from these plateaus was by converting it into whisky or live stock. Owing to the fact that the United States Government taxed whisky, there has been for more than a century a struggle between the collector of revenue and the illicit distiller, the "moonshiner" as he is called, of the Appalachian Mountains. The mountaineer felt that it was a tyranny for the government to tax the thing he could sell easiest. This feeling took its strongest form in Washington's administration, when the people of western Pennsylvania, objecting to the tax, arose in insurrection against the new Republic in the so-called "Whisky Rebellion." This feud with the government still lives.

[2] It is estimated that the total area of corn harvested in the world in 1939 was about 219 million acres, as compared with 405 million acres in wheat.—U. S. Dept. of Agriculture, *Agricultural Statistics, 1942*, Washington, 1942, pp. 15, 57.



A

The study of these two temperature maps brings out the interesting fact that most of our corn grows in lands of cold winter and hot summer. In frost land, nature locks up its fertility with freezing—keeps it in the refrigerator till spring.



B

A considerable part of the United States has summer weather that is, for that time, essentially tropical or near tropical. Note the close relationship of the limits of the Corn Belt to the summer temperature above 69°.

This is an excellent map to show the advance of spring in all the country east of the Rocky Mountains. In the mountain area, the corn-planting days are shown by a common fraction—date above and altitude below.

Corn for extensive production is not planted much after the first week in May.

and a frostless season of more than 140 days.

For optimum growth and grain production, corn needs a plentiful supply of moisture well distributed throughout the growing season, maximum yields in this country being obtained where there is a monthly rainfall of 3 to 6 inches during June, July, and August.[3] In our Corn Belt the annual precipitation varies from 25 to 50 inches, 7 inches falling in July and August.

Although a lover of heat, corn does not do its best in the tropics or even in the prolonged summer at the mouth of the Mississippi River, or in Florida, where the corn grows tall but the yield of grain is low. It seems to require a seasonal warning that cold weather is approaching. It must get ahead of cold weather. The rapidly shortening hours of daylight in northern latitudes serve notice to the sensitive plant that winter is on the way, and cause it to turn its energies from leaf production to seed production. For this cause, apparently, the yield of grain is often larger on the northern margins of the Corn Belt than in its warmer parts, or in the tropics where length of day varies little from season to season.[4] As a result of careful studies Ellsworth Huntington claims

[3] The United States Department of Agriculture says that of all causes of damage to the growing corn crop, deficient moisture is by far the greatest. The average loss through deficient moisture over a ten-year period was estimated at 666 million bushels yearly.

[4] Through many generations of selection, the strains of corn grown in different latitudes from the Equator to the northern and southern limits of corn growing have become adapted to the length of day in the locality in which they are grown. When tropical varieties are grown in our

that Connecticut has the best corn climate in the United States. It's too bad that Connecticut is so small and so largely composed of stone.

Although the growing of corn is very widely distributed, seven major zones of production may be recognized: the American Corn Belt of the upper Mississippi Valley, the American Cotton Belt, the highlands of tropic America, the Black Sea Basin, the Mediterranean countries, southeastern Asia, and the lower Paraná Valley of Argentina (see Fig. 452A). Among these major zones of production, the American Corn Belt is by far the most important.

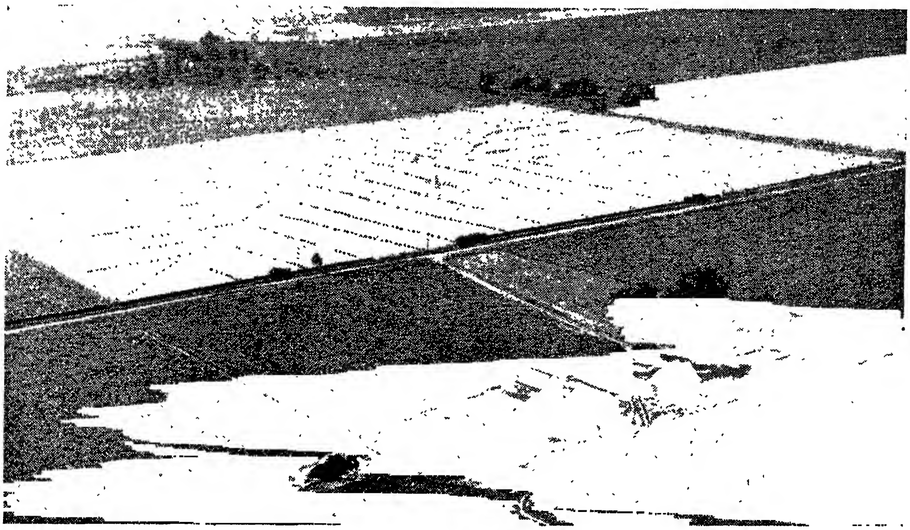
The American Corn Belt. Corn is grown from the Gulf of Mexico to the Great Lakes, and from the Atlantic Ocean to western Kansas and in scattered areas beyond, but the region of greatest production is the Corn Belt, which reaches from central Ohio to central Kansas, and from Kentucky to central Wisconsin and southern Minnesota. It includes all the state of Iowa, nearly all of the states of Missouri, Illinois and Indiana, about half of Ohio, Kansas and Nebraska, and parts of South Dakota, Minnesota and Wisconsin. This region is one of the finest agricultural sections in the entire world. Hundreds of miles of almost level prairie are rarely varied by undulations steep enough to interfere with the laying out of roads on meridians and parallels at regular intervals of one mile. This soil that lies so beautifully for tillage is naturally fertile, and so free from stones that the worker can ride the cultivator with which he tends the corn. Some of these cultivators till both sides of four rows of corn at once. Thus, an unaided farmer can cultivate sometimes more than 100 acres and produce the grain that was so wonderfully cheap for many years. Serious droughts are infrequent in the Corn Belt. The abundant rainfall of summer comes in short showers which do not seriously interfere with agricultural operations, and the heat is sufficient to make a most excellent growth of corn.

Relation of Corn to Other Products of Corn Belt. Corn is not the only crop in the Corn Belt. On a single farm there will be, in addition to corn, fields of oats or wheat and hay which require the farmer's labor at different seasons from the corn; also there will be a field of grass upon which cattle can graze.

A surprisingly small portion of the Corn Belt grain goes directly to the market. Whereas more than 70% of the wheat crop of the United States is consumed as human food, the remainder being used for feed, seed, and other purposes, the reverse is true of corn. About 80% of the corn is grown as a supply crop, fed to animals on the farms where raised, and sold in the more condensed forms of beef, pork, lard, mutton, horses, and mules. The biggest corn-growing states are also the ones which market the major share of the fat hogs and cattle.[5] Near the great mar-

Corn Belt, they do not flower until fall when the days are short. Plants of a tropical variety grown at Arlington, Va., subjected to an artificial 8½-hour day for 34 days beginning the last week in June, began flowering during the second week in August, whereas those grown with the natural day length did not flower until late in September. —See Merle T. Jenkins, "Influence of Climate and Weather on Growth of Corn," *Yearbook of Agriculture, 1941*, U. S. Dept. of Agriculture, Washington, 1941, p. 315.

[5] The six states: Iowa, Illinois, Nebraska, Missouri, Indiana and Ohio, producing 57% of the corn in 1942, had within their borders about 54% of the swine of the country.



We look down on the Corn Belt. The farmstead in the foreground is entirely surrounded by corn save for a small hayfield between the house and the highway. The big field across the road shows the rows of oat shocks. To the right of it is a field of unharvested oats, and beyond to the horizon, more farmsteads and more corn and oats. An interesting land to travel through in July when oats are being harvested and threshed or in autumn when the corn is being gathered.

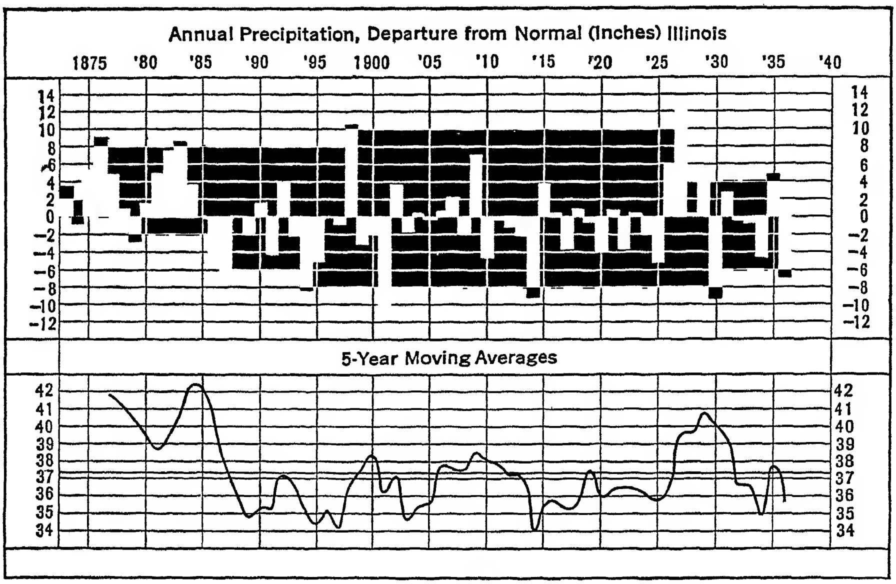
kets where the transportation is cheaper, as in Illinois, the proportion of grain sent directly to market is much greater. During the ten-year period, 1930-40, about 34% of the corn of Illinois was shipped out of the county where it was produced. In Kansas the corresponding figure was only 9.3%, and in Texas it was 9.5%, these states being located much farther from markets than Illinois.

Many million bushels of corn are used in distilleries, making legitimate alcohol, and a substantial amount of hog feed remains in the refuse. Corn oil is also a brisk contestant in the hot race of vegetable oils toward their goal in the American frying pan. Other entries are the peanut, soybean, and cottonseed, all running strong, and unlike human beings, not perturbed by the prospective fate in the fiery furnace.

The Improvement and Extension of Corn Growing. Great improvement in corn growing takes place from year to year as the scientific agriculturalists breed new and better varieties and select the seed to take advantage of the known laws of heredity. In a measured test in Illinois one large field yielded 48 bushels to the acre and a similar adjacent field yielded 77 bushels to the acre, and the only element of difference was in the superior well-selected seed that produced the larger crop. Since 1933 hybrid seed corn, yielding about 30% more grain per acre than ordinary open-pollinated corn, has been widely adopted in the Corn Belt, and in 1943 approximately 50 million acres, or 52% of the total corn acreage in the United States, was planted with hybrid seed.[6]

The only significant corn frontiers we

[6] In 1943 the Corn Belt had 46 million acres planted with hybrid seed.—U. S. Dept. of Agriculture, *Hybrids Dominate Corn Acreage*, mimeographed circular, Washington, July 10, 1943.



The upper graph shows excess and deficiency of annual precipitation in Illinois with regard to average rainfall; average is shown by the line. Similar figures from other parts of the world would show a much greater fluctuation. The dependability of Illinois rainfall is a factor in making it so important in our corn crop.

The lower graph shows a five-year moving average. The really significant thing is to note the excess in the period from 1876 to 1887. That period of heavy rain extended much further west. It broke the hope and wrecked the finances of many a family tempted by it to move into lands too dry for the period that followed, with the deficiencies of the 1890's. The graph for 1930 shows one of the worst droughts that the Middle West has had since settlement.

have opened since 1895 have been those on the north, and the gradual extension of the Corn Belt northward has been chiefly due to the use of these earlier maturing varieties. For example, a variety of corn known as Minnesota No. 13, which ripens in thirteen weeks after it is up, was perfected in one of the Minnesota experiment stations and with a number of other varieties is steadily permitting corn to grow farther north.[7]

It has only been within the last three decades that South Dakota and Minnesota have become large corn-producing states.[8] South Dakota, long known

[7] Mr. M. R. Gilmore, authority on Indian agriculture, bewails the stupidity of the white man who brought to the West and the Northwest the strains of corn he secured from the first Indians he met, namely, those of the Atlantic coast. Centuries ago the Indians had adjusted corn to the particular climates and were growing it far beyond our Corn Belt and well up into the present wheat region of Canada—varieties which have not thus far been made the basis of agriculture.

[8] Production of Corn:

	Minnesota		*South Dakota*	
	Million acres	*Million bushels*	*Million acres*	*Million bushels*
1907	1.6	43.6	1.8	47.1
1914	2.6	91.0	3.0	78.0
1923	4.3	154.7	4.2	145.1
1943	5.2	215.5	3.5	79.7

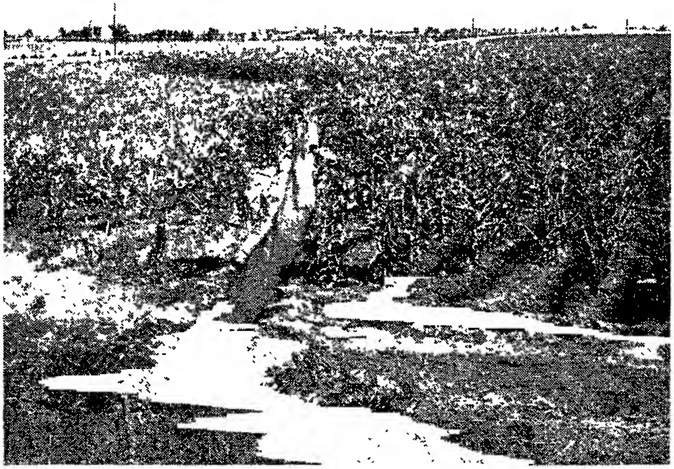
Part of this corn production is made up of the estimated number of bushels used in the making of silage, but according to the United States Department of Agriculture estimates, not more than 15% of the crop is cut green for feed or silage.

chiefly as a wheat state, now grows more than 2 bushels of corn to every bushel of wheat. Another way of extending the area and value of corn production, especially in cool climates, is offered by the silo. This device, first introduced from France, is a barrel-like structure, 10 to 20 feet in diameter, made of wood or concrete. Its use is rapidly on the increase, because the entire plant, stalk, leaf, ear and husk, when chopped into bits, may be kept moist, warm, and edible for cattle for one or two years. In this form, called silage, corn makes its greatest possible food return to ruminant animals, is much used in the feeding of dairy and beef cattle, and, since it can be put away some weeks before it is fully matured, can be grown much farther north than can the ripened grain, which can be kept only after fully maturing in the field.

In the short summer of New England, the silo helps in a suggestive industrial combination. While corn may not ripen, it easily and surely gets ready for table use—the so-called roasting-ear stage—so that from a field of sweet corn wagon loads of ears may go to the canning factory or the vegetable market, and the stalks are put into the farmer's silo to feed his dairy cattle—an important fact in systematic agriculture. Further than this, the canned corn of the north is in some markets recognized as of superior quality because the cold climate delays ripening, gives a longer period in the edible milky condition, and thus gives better opportunity to harvest it in its best edible form.

Corn in the Cotton Belt. Corn is the second crop in importance in the cotton lands of the South, but cotton is so overwhelmingly the main crop that the corn crop is often insufficient for local use, and import from the Corn Belt is necessary. Corn, but little used as human food in the northern half of the United States, is in common use in the southern states and is often the chief breadstuff of white and black alike. Its excellence for the support of human beings is unquestioned by physiologists, and this was well shown by the endurance of regiments of soldiers in the Confederate armies during the American Civil War. Nevertheless, corn is generally unappreciated as food outside of the southern states, except in regions where the people are poor, as in Italy, Rumania, Hungary, and Mexico, where it is used because it is cheaper than the other breadstuffs. Two culinary shortcomings suffice to explain its small use: it has no gluten and will not make a dough, or light bread; second, the bread loses much of its palatability, though not of its nutrition, upon getting cold. Cornmeal gruel or mush called "polenta" is a staple article of diet for large numbers of Italians, and millions in southern Europe are poor enough to relish cold corn bread.

American Corn Exports. Although the United States is truly the Kingdom of Corn, producing over half of the world's corn each year, only about 1% of our annual output of approximately 2½ billion bushels is normally exported as grain. Most of our corn is exported in concentrated form—pork, lard and lard compounds, beef, and mutton. From an average export of 195 million bushels in 1896-99, our trade declined to 41 million bushels in 1910-14 and to 31 million bushels in 1934-38. In 1940 our net exports of corn amounted to 37

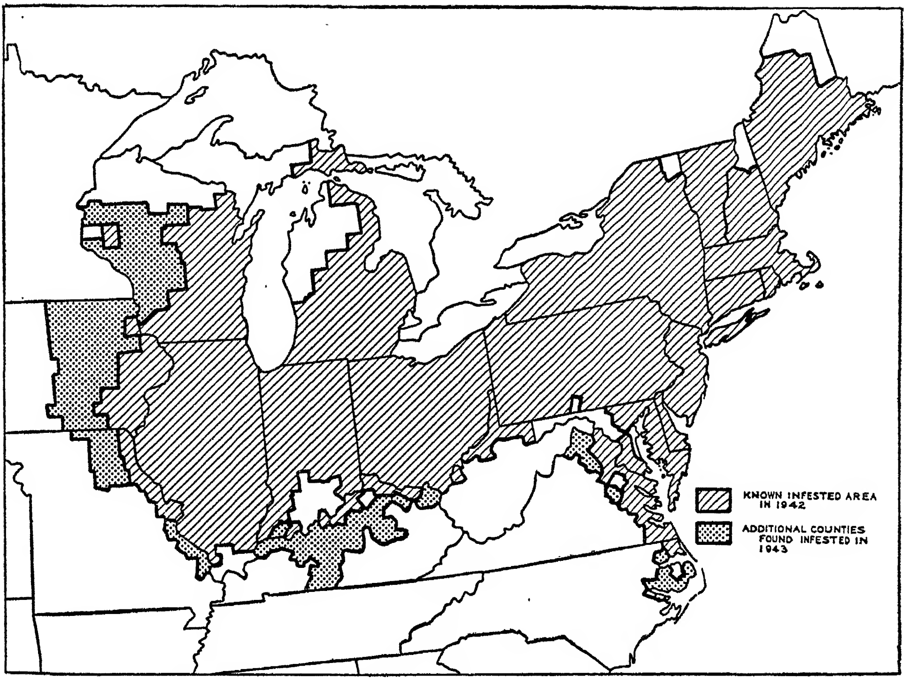


A

Nebraska, 99⅓° W., rainfall that year 18.96 inches, during the growing season 13.81. A few slight irrigations on the right side of the ditch made 50 bushels of corn to the acre and on the left side of the ditch, the unirrigated land produced no corn and almost no fodder. Such facts are one of the arguments back of the gigantic plan for the hundred reservoirs in the Missouri Valley.

B

Texas corn and cotton land—Houston clay and gravelly soil, only 4% slope, but 25 to 75% of the topsoil has been removed by erosion in a few decades. The soil conservation plan here in evidence shows at the extreme margins terraces held by heavy grass. Winding through the center is an ungrassed terrace, heaped up by road-making machine. The fact that these rows are horizontal causes the furrows to hold the water and allow it to soak in before it starts to run. Grassed runways are provided at the end of the terraces. This represents an American bid for survival, but it comes too late for millions of acres.



This age of world commerce brings us food and raw materials from the ends of the earth. It brings us seeds of new crops from the ends of the earth and alas, also, it brings us pests from the ends of the earth. We have 150 imported weeds; the Hessian fly that destroys wheat; a host of orchard bugs and blights; the cotton boll weevil, and—here we see one year's advance of a new one—the European corn borer. Fortunately this is a pest, rather than a major calamity, such as the cotton boll weevil has proved to be.

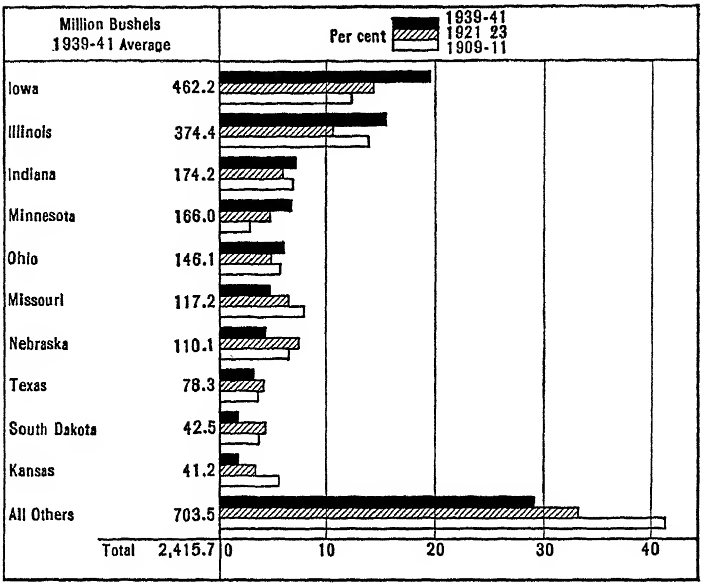
million bushels. Corn is almost always sent from the region of heaviest production in our Corn Belt, first being assembled in the markets of St. Louis, Kansas City, Omaha, or Chicago. From these points it usually moves by railroad to the Atlantic ports between Norfolk and Montreal for export to the countries of northwestern Europe, where it is used as feed for livestock on farms.

At various times exporters of corn from the United States have attempted to spread the habit of corn eating among the peoples of northern Europe, but without success.[9] This is due chiefly to the conservatism of all peoples toward changing their diet, and partly because of the above-mentioned limitations of corn as a breadstuff.

The home demand for corn, however, promises to remain large. We have in this country an increasing population, used to a high standard of living, and with a high per capita consumption of corn-fed meats. As we have no new corn lands to turn to and some of the old ones are declining in productivity, we seem to have reached the end of an era of cheap corn.

As an exporter of corn, the United

[9] Even during World War I, when there was a great demand for breadstuffs in impoverished Europe, the attempt to introduce corn as a human food among wheat-eating peoples was a failure.



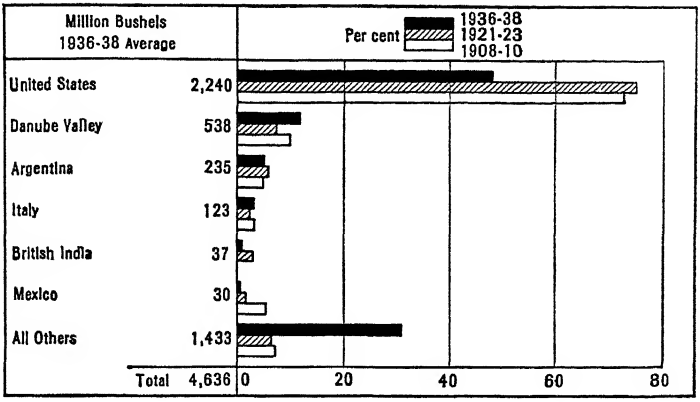
United States corn production, by leading states, three-year averages, by per cent for three periods and bushels for the last. The humid states, Iowa, Illinois, Indiana, Ohio, hold their own or gain. Minnesota gains. West of the Missouri River note the decline, but sorghums are booming from North Dakota to Texas.

States is greatly surpassed by Argentina, which, with shipments averaging 257 million bushels a year, in 1934-38 accounted for more than one-half of the world's corn export trade.[10] American corn exports are usually followed in importance by those of Rumania, French Indo-China, Yugoslavia, and the Union of South Africa. It is estimated that during the years 1924-38 only 8.8% of the world's total production of corn entered into international trade,[11] which shows clearly that the great bulk of all corn is directly consumed in the countries where it is grown.

Corn in the Highlands of Tropic America. The Spanish-American highlands, reaching from the boundary of the United States to Argentina, comprise the third corn growing zone. No corn is exported from these countries, and little is raised for stock, since the animals usually graze the year round. In every one of them—Mexico, the six Central American countries, Colombia, Ecuador, Peru and Bolivia—the bulk of the population, native Indians or half-breed peoples, derive their nourishment to a surprising degree from corn and beans. Many of these Indians and half-breeds, known as peons, have a very low standard of living. The simplest shelter suffices and rather than work much, they content themselves with beans, one of the most easily grown of vegetables, and corn, the cereal which

[10] Henry C. Taylor and Anne D. Taylor, *World Trade in Agricultural Products*, The Macmillan Co., New York, 1943, p. 147.

[11] *Ibid.*, p. 139.



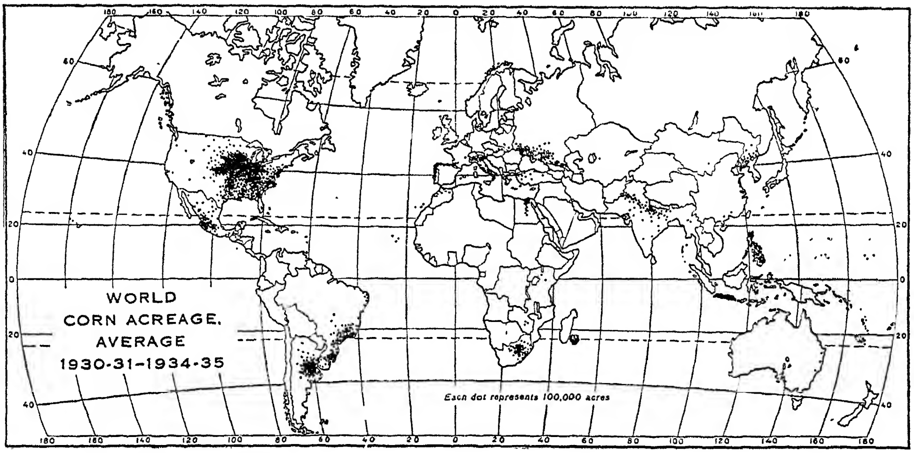
World's corn production, three-year averages, by per cent for three periods, by bushels for last period. Note how others have come to the front, while the United States has gone backward since the government gave the farmer a chance to get in on the scarcity economy by cutting down our corn production in the 1930's.

they can most easily and cheaply grow, and some leaf greens to furnish bulk, vitamins, mineral salts. In Mexico and other of these countries the commonest form of corn bread is the "tortilla" or hot corn cake which can be baked over an open fire.

In these countries the population is chiefly on the plateaus, where the topography is often broken. The corn fields are usually small, and the production, which is almost always for local consumption, resembles the family garden rather than the broad fields of the American Corn Belt. Some of these plateau patches are of great fertility. It is said that there are certain fields in Ecuador where the soil, made of dust blown from the volcanos Chimborazo and Cotopaxi, has yielded crops of corn continuously for over 200 years. There is no prospect that corn will ever be grown for export from these countries. The development of their resources will follow other lines. All Mexico north of San Luis Potosí imports corn in times of peace when the mineral resources and railroads give employment to workers, in spite of the fact that the Mexican output of 70 to 80 million bushels a year is about equal to the combined output of all other countries within this corn-producing zone.

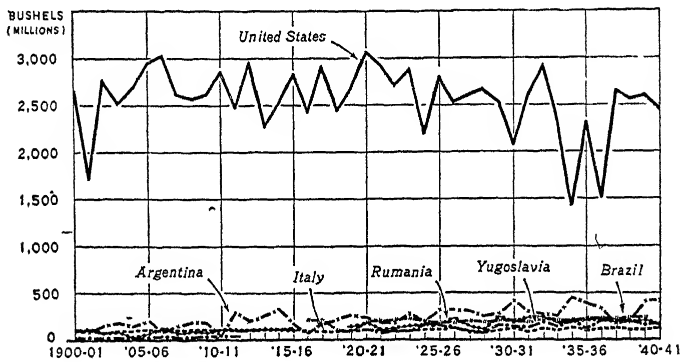
Among the Negro population of the West Indian Islands, corn is widely used for food, but not enough is grown for home use, and here, as is sometimes the case in Yucatan, there is a relatively large import of corn and cornmeal from the United States.

The Corn Region of the Danube and Black Sea Areas. The corn zone second in importance to the United States Corn Belt is that of the lower Danube Valley and throughout an area extending through Bessarabia eastward along the north coast of the Black Sea and into the Caucasus. The crop of this region is about 550 million bushels a year, less than one-fourth of the output of the United States. Although occupied by several different nations, the lower Dan-



A

This map shows where the world's corn is grown. France has a little strip between the north, which is too cool in summer, and the south or Mediterranean section, which is too dry in summer. In Russia and Rumania this band widens, but unfortunately for Russia, it doesn't go very far inland.



B

The map showed location, this graph shows quantity and the towering pre-eminence of the United States. There is but one Corn Belt par excellence, and we have it.

ube Valley is, like our Corn Belt, one economic region. Corn is extensively grown on the great fertile plains of Hungary, Rumania, Yugoslavia, Bulgaria, and the Black Sea area of southern Russia. Further to the eastward the climate becomes too dry for corn (but not for wheat), and in the lower Volga Valley, east of the Caspian Sea, the aridity is too great for tilled crops.[12] The greater part of Russia and the regions to the north of the Danube Valley and to the west of Hungary are too cold for significant corn production. There is also some corn grown in the more hilly part of the Danube drainage basin on the slopes of the Balkan Mountains in Yugoslavia and Bulgaria. Prior to World

[12] The eastward succession of corn, wheat, and pasture regions here is an exact duplicate of the westward zoning of the same in Kansas.

War II, Rumania owned the fertile province of Bessarabia and led this region in corn production with an annual output of approximately 200 million bushels, or about half as much corn as is produced each year by our leading corn-growing state of Iowa. In prewar years Yugoslavia and Russia each produced about four-fifths as much corn as Rumania, the output of Hungary and Bulgaria being much smaller. The bulk of the population in this entire region is rather poor, and they depend for breadstuff almost entirely upon corn, and in normal times they export to western Europe the wheat which is grown as a cash crop.

In prewar years Rumania normally harvested about 12 million acres of corn with an average yield of 17 bushels per acre and about 9 million bushels of wheat averaging 14 bushels to the acre. These Rumanian yields are much lower and fluctuate more from year to year than those in our Corn Belt states,[13] an indication of inferior production methods and poorer climate. In contrast with scientific seed selection, mechanized production, and other modern practices in the American Corn Belt, Rumania is a land of peasants using oxen as work animals. The Rumanian Corn Belt is more accessible to water transportation and market than is that of the United States, and in 1934-38 Rumanian shipments averaging 21 million bushels a year caused that country to rank third among the corn exporters of the world. The Black Sea Basin is a land where droughts come with ever-increasing frequency as one goes eastward, a factor that increases the uncertainty of corn yields. When production in the Danube Basin resumes prewar figures, exports from this source are likely to increase.

Corn Production in Mediterranean and Adjacent Regions. Most of the Mediterranean region is too dry in summer for the growth of corn except under conditions of irrigation. The large yield of corn per acre, however, makes it greatly desired as a crop by peoples poor enough to use it as their chief food. Italy with more than 100 million bushels a year (about equal to Missouri) is the leader, producing nearly twice as much as Spain, Portugal and the south of France combined. Whenever corn can be irrigated it is grown for home use, largely as human food, in Turkey, Greece, and Egypt, where it is an important crop; but the dense population of Egypt consumes nearly all of the 60 million bushels of corn produced along the lower Nile. The plains of northern Portugal and northwestern Spain near the ocean have rainfall sufficient for mediocre growth of corn without irrigation, the combined output of these two countries being about equal to the crop of North Carolina.

The desert heart of the Old World and regions adjacent to it, reaching from southern Morocco across North Africa, Arabia, Persia, the deserts of central Asia and Gobi to the Great Wall of China, can, as in Egypt, produce corn only where irrigation can be practiced. The people of the Barbary states grow some corn, as do those of Palestine and Asia Minor. It is grown to some extent in Persia, and it is relatively important to Bokhara and other oases of

[13] Illinois corn yields: 1930-39 average, 36 bu. per acre; 1941, 45 bu. per acre. Illinois wheat yields, 1930-39 average, 18 bu. per acre; 1941, 20 bu. per acre.

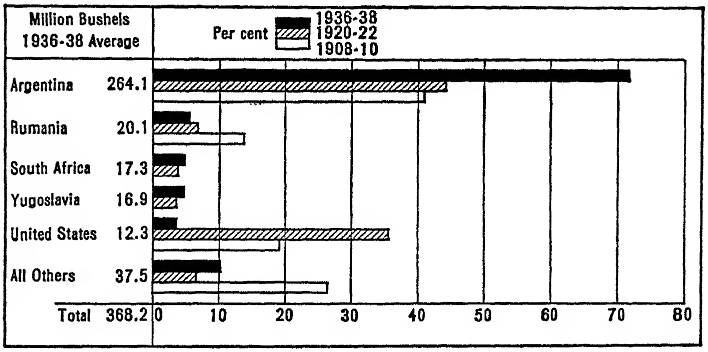
Russian central Asia and Turkestan. In all of these regions it is prized as human food.

The Corn Belt of Southeastern Asia. The sixth corn zone is to be found in the moist countries of southern and eastern Asia. In the drier part of the monsoon countries, especially China and India, there are districts that suit corn much better than they suit rice. For example, Peiping is almost the climatic duplicate of Omaha. It is believed that China produces more than 240 million bushels of corn a year, the maximum center of production being the Great Plain of North China including the lower Hwang-ho Valley. In the northern part of this plain corn is the major summer crop and is interplanted with soybeans after the wheat harvest in late May or early June. India produces about 85 or 90 million bushels of corn a year, most of the crop being grown on the alluvial soils of the middle and upper Ganges Valley and on the irrigated lands of the Punjab. Corn is grown in southern and central Manchuria, and in some areas it replaces kaoliang and millet as the leading food. Indeed, some of the battles of the Russo-Japanese War were fought in fields of standing corn. Even tropical Java is growing as much corn each year as Texas, and the Philippines raise two-thirds as much as Maryland. Among the Asiatic countries, only French Indo-China (pop. 24,000,000) has a sizable surplus of corn for export.

The Paraná Valley and Brazil. The seventh and last corn zone lies west of the lower Paraná River in Argentina. Although the Argentine Corn Belt is similar to that of the United States in some respects, there are many important differences. The Argentine belt is much smaller, occupying approximately 30,000 square miles, or about one-eighth of the area of our Corn Belt. It is roughly 250 miles long from north to south and extends westward from the great bend of the Paraná River for about 120 miles to the edge of the Wheat Crescent.[14] Within this compact area is to be found the most fertile soil of the humid portion of the Argentine pampa. As in the American Corn Belt, summer temperatures are high, averaging between 71° and 75° F., but the winters are much milder and permit winter plowing in July, August, and September, and planting may continue until December. This region receives from 28 inches of rainfall on the west and south to 38 inches on its eastern margin, but droughts are more frequent than in our Corn Belt. In Argentina droughts are often a double calamity accompanied by incredible hordes of locusts, which invade the region from the north and west and devour almost all vegetation in sight. On the other hand, excessive rainfall sometimes occurs late in the summer and interferes with the ripening and harvesting of the grain.

On the large Argentine farms, which are operated by tenant farmers or sharecroppers, one finds fields of corn, wheat, flax, and alfalfa hay, flax replacing oats found in the typical crop combination

[14] Corn production has not penetrated the area east of the Paraná River owing to the existence of much poorly drained land, a lack of good overland transportation, and the persistence of huge cattle *estancias* which are seldom sold or subdivided for agricultural use.—See Clarence F. Jones, "Agricultural Regions of South America," *Econ. Geog.*, vol. 4, January, 1928, p. 15.



World's corn export by three-year averages, percentages for three periods, bushels at the last period. We have abandoned for the time at least the old course of supply and demand and upped the price of corn by government action. Argentina did not. Also the roving Argentine tenant farmer uses corn as a money crop, as the Kansas wheat farmer uses wheat. Growing corn and feeding it to livestock is a different sort of enterprise than merely growing corn.

of the American Corn Belt. Corn occupies more than one-half of the total crop land, and along the Paraná River north and south of Rosario as much as 75% of the crop land is devoted to corn.[15] The Argentine farmer seems to have a perennial shortage of labor and is dependent upon migratory workers to help with the harvest. While the American Corn Belt lies in the heart of the continent, the Argentine belt has much easier access to the sea, and tramp ships come up the Rio de la Plata to Buenos Aires or on up the Paraná River to Rosario where they take on full cargoes of grain destined for northwestern Europe. With an annual crop usually exceeding 300 million bushels, Argentina often ranks second only to the United States as a producer of corn. About three-fourths of the crop is exported. The number of corn-consuming hogs is less than half the number found in our state of Iowa. The hog is not a roving sharecropper's crop. Argentina is said to suffer greatly from absentee landlordism and a malignant form of sharecropitis. Argentine cattle graze on pasture lands most of the year and are fattened with alfalfa, and the Argentine people eat wheat. Although Argentina produces only about one-ninth as much corn as we do, her corn exports are 6 to 10 times larger than ours.

Brazil vies with Argentina for second place among the world's leading producers of corn, three-fourths of the crop being grown in the states of Minas Gerais, São Paulo, and Rio Grande do Sul. In contrast with Argentina, Brazil does not export corn, which combines with rice, beans, and mandioca to form the chief food of the common people. Brazil has more than 3 times as many people and 8 times as many hogs to feed. The Brazilian corn crop has greater cash value than the much-talked-of coffee.

[15] Ray H. Whitbeck and Frank E. Williams, *Economic Geography of South America*, McGraw-Hill Book Co., Inc., New York, 1940, p. 362.

2. *Rye*

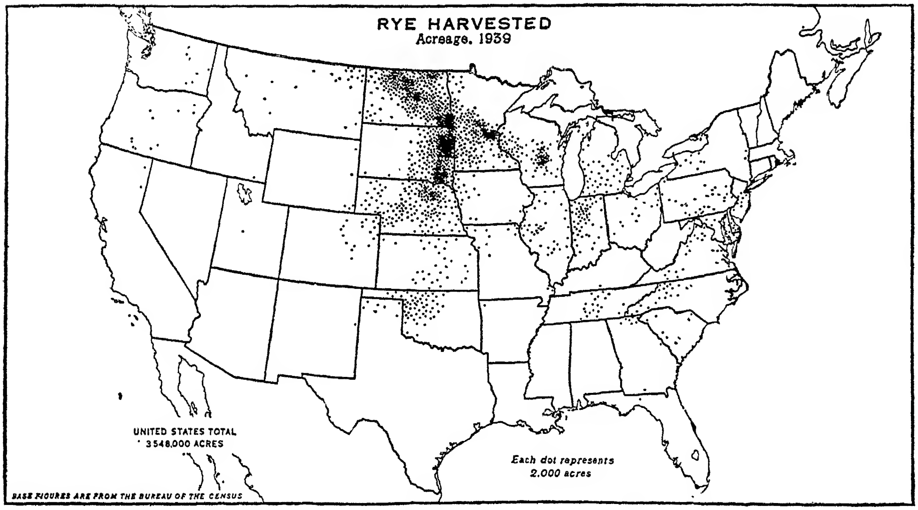
Rye Compared with Wheat. Botanically, rye is closely allied to wheat which it resembles, but the grain is smaller and darker, less nutritious, and hence less valuable. That the prewar production of rye was about one-fourth that of wheat for the whole world is due to the fact that under certain conditions it will produce more food per acre than wheat. It is hardier, as shown by the fact that the rye belt of North America runs 300 miles farther north than winter wheat. In the spring wheat region rye enlarges farm activity by providing a fall-sown crop which can be harvested before wheat is ready. Rye also grows more successfully on thin, sandy or sour soils, and is less affected by rust and insect pests.

Uses. The chief use of rye is as a breadstuff, primarily for people with a low purchasing power and consequent less expensive standard of life. For example, in central, north, and northeastern Europe rye is the chief breadstuff of the poor, as Indian corn, the cheap grain of the warm land, is in parts of south Europe, the Danube Valley, and Mexico.

Regions of Production. The region of the world's greatest rye production is in the low plain of north Europe reaching from the English Channel through Holland, Belgium, Denmark, Germany, Poland, and Russia to the Ural Mountains. Owing to the work of glaciers, which once covered this part of Europe, the soil is in many places sandy and poor. Here rye grows better than wheat. Russia sometimes grows more rye than wheat, which explains her large export of wheat, as the people eat the rye. Prior to World War II, Russia alone produced nearly half of the world's rye crop, Germany more than a sixth, and the United States, with its 40 million bushels, about one-fortieth. Austria and Czechoslovakia are also rye growers. In 1939 Germany grew nearly twice as much rye as wheat. The peasants and factory workers of rye-growing countries eat the most of it in the form of black bread, which, after all, is nearly as nourishing as wheat bread, and more nourishing than much of the white bread eaten in America. But these people frequently substitute the esteemed wheat bread for rye bread, when they become able to buy wheat.

As it grows with little care and on rough ground, rye was an important crop to the early settlers in the northeastern United States, but after the opening up of the fertile level West, it was neglected in favor of wheat. During the last 25 years rye growing in this country has fluctuated greatly, our average annual output varying from 38 million bushels in 1909-13 to 88 million bushels in 1921-25, 31 millions in 1930-34, and 56 millions in 1939-42. In recent years our rye output has been about one-fifteenth of the size of our wheat crop. While it has held its old place in the poorer lands of the East, southern Michigan and Ontario, the significant increase has been in the northern spring-wheat belt (see Fig. 457). Canada, with conditions resembling those of the United States, has also had a recent increase in rye production. This is a natural response to the demand for more grain.

From the standpoint of crop rotations and farm practice, including mechanization, rye, oats, and barley are sim-



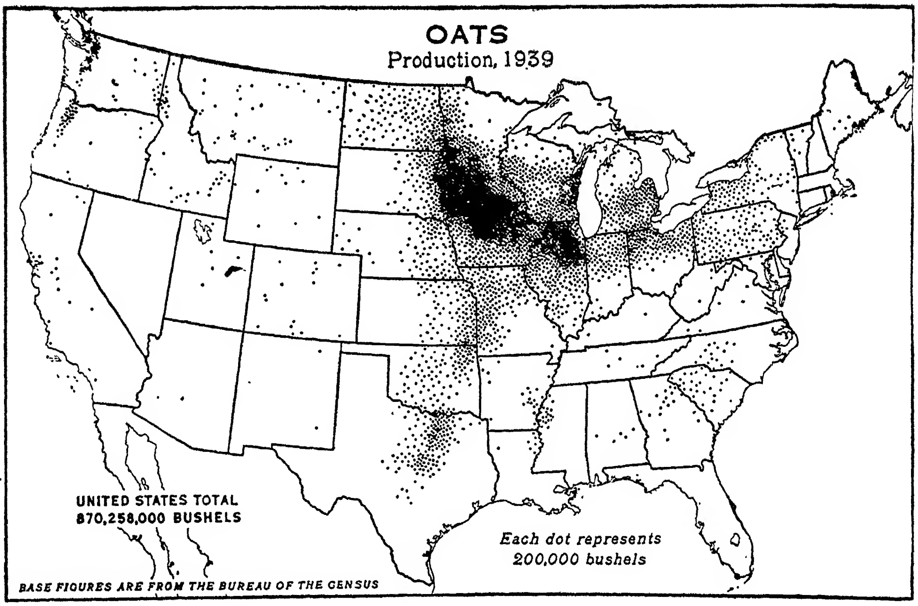
In comparison to wheat, rye is one of the goats of the cereal group, able to stand more frost and more sandy soil. Where rye is important, wheat is not so important. Notice southeastern South Dakota, central Nebraska—where there is no wheat at all, because it is between winter wheat and spring wheat—a sand area in central Wisconsin, and scattered plantings in the Appalachian area.

ilar to wheat, but call for harvesting at slightly different times.

3. Oats

Regions of Production. Among cereal crops in the United States oats stand second to corn and above wheat in output. The soil requirements of the oat plant are not unlike those for wheat. In its climatic requirements it can stand nearly as much heat, but being nearly always spring sown it has a later growing season and requires more rain. It can be fall sown in southern United States and may increase in use there. Ordinary threshing machines leave the oat grain protected by a husk. This helps the crop in damp climates. It will also grow in a colder climate than wheat. Its moisture requirement bars it from the Mediterranean climates with their hot dry summers. Because of these qualities, it is grown to some extent in very nearly all the important northern wheat regions and also in rye and northern barley regions. It is of the greatest relative importance in such cold, damp countries as Ireland, Scotland, Sweden, and Norway, and is grown to a great extent also by the people of the central and eastern European rye belt. It is also important throughout Canada, where the climate is too cold for corn. In the colder northern parts of Korea and Japan where rice does not thrive and wheat is not at its best, the farmer resorts to oats and barley. Since World War I, Japan has doubled her oat crop, while barley remained static.

Uses of Oats. The Scotch, probably because of their moist climate, have most largely utilized the oat as human food. Dr. Johnson's famous English dictionary is said to have defined oats as "food for men in Scotland, horses in England," to which the unbeatable



Oats. This teammate of intensive corn fits into the corn crop especially well where the corn is harvested by machinery too late in the autumn for a winter grain to be sown. In parts of the south oats becomes a winter grain but acreage is not very important yet.

Scotch replied, "And England is noted for the excellence of her horses, Scotland for the excellence of her men." The farm laborers of Scotland are said to have almost lived on oatmeal and milk in some areas and at some periods. The people of other countries are now, since the coming of the breakfast food habit, learning to eat more oatmeal. A little oaten bread is used in parts of north Europe, but the main use is as horse feed. Oats are seldom raised as a cash crop and are usually fed on the farm where grown.

Grown on Same Farm as Indian Corn. The fact that oats are better adapted to corn farming crop-rotation than any other small grain makes them very important in the Corn Belt of the United States. In much of this territory the summer is not fully suited to spring-sown wheat, and the alternate freezing and thawing of the open winter often injure winter wheat. Oats, not being hurt by a little frost, fit nicely into these climatic and agricultural conditions by being sown very early in the spring before corn can be planted. Since it is not necessary to plow the seed bed, where oats follow corn, this crop permits great economy of labor. After seeding they require no attention until harvest time, which does not occur until after the corn has been planted and has received its cultivation. Then while the corn is maturing, after the hay harvest or possibly before it, the oats are harvested. The excellent way in which these crops dovetail together makes the field of oats as well as the field of corn and the field of hay a part of the great Corn Belt farm system, and here is grown the greater part of the United States crop, which in 1939-42 averaged

about 1.2 billion bushels a year. In appraising crops statistically, it is well to remember the legal weights of the bushel. In the United States a bushel of oats contains 32 lbs., corn 56 lbs., and wheat 60 lbs.

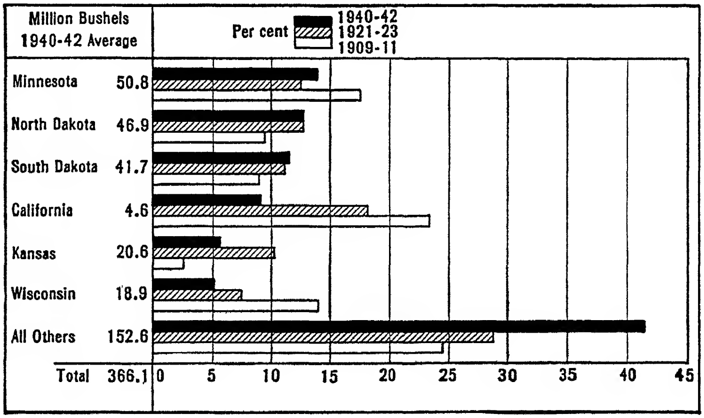
The oats crop of the United States is now almost equal to the production of all Europe. The prewar Russian crop was slightly larger than that of the United States, and the German crop was about one-third. In 1942 Iowa, Minnesota, Illinois, and Wisconsin produced about half of our oats crop of 1.4 billion bushels.

Effect of Light Weight on Export. The oat grain has a thick, light, close-fitting husk which is not removed by ordinary thrashing. It is left upon the grain if used for animals and only removed by special machinery when the grain is prepared for human food. The large bulk per unit of value is one of the reasons for the small export, which in the United States amounts to less than a twentieth part of the crop. Another and greater reason for the small export from America is the great importance of oats in the agriculture of the grain-importing countries of western and northern Europe.

Oatmeal makes up an important part of the American export of oats, the centers of manufacture being in a number of small towns in Iowa and other Corn Belt states, from which the familiar little pasteboard boxes go out in millions, while the more economical sacks and barrels also take their share.

4. *Barley*

Character, Range, and Hardiness of Barley. This is the hardiest of the important cereals. The wheat limit in Russia is near Leningrad, but barley goes on to the Arctic. It is neighbor alike to the sledge-drawing reindeer and the desert-crossing camel. In the appearance of the growing plant and of the

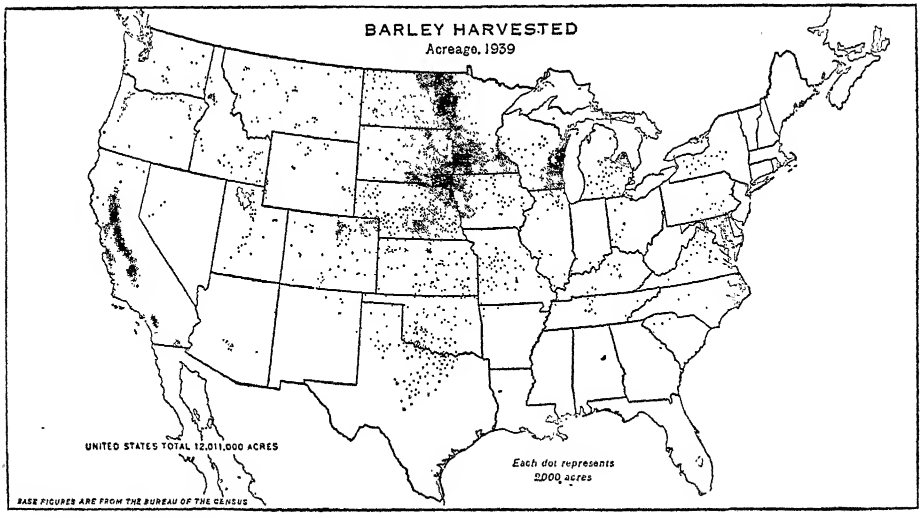


Barley is rye's brother in the goat class among small grains. Its specialty is to withstand drought, but it has lost ground to fruit in California, to sorghum in Kansas and to the silo in Wisconsin. It has, however, made friends in other states as shown by the increase in "all other." Its chief functions are for brewing and as forage grain, for which use it is a rival of corn and the heaviest yielding of the small grains.

seed it bears close resemblance to wheat. Under similar cultural conditions the yield per acre is much greater than wheat, with the advantage of wider climatic range. Barley is important in northern Norway and Sweden, and in the adjacent Lapland, growing beneath the midnight sun, and ripening 150 miles beyond the Arctic Circle in 70° north latitude. It is regularly grown in Finland and north Russia to the shores of the Arctic Ocean, and its ability to resist droughts and heat causes it to be grown as far south as the Nile Valley, parts of the Sudan, Ethiopia, and the east point of Africa near the equator.

Uses. An essential element of breadstuff for general use is gluten, which permits the making of the sticky dough necessary to impound particles of gas and make light bread. But for its shortage of gluten, barley would probably replace wheat as our dominant breadstuff. In this connection we should remember that scientific plant breeding, a great engine of production, is only one-fourth as old as its brother the steam engine. The large yield of barley in combination with its ability to resist drought made it the chief grain food of the ancient Hebrews, Greeks, and Romans, who had rather dense population in lands with a very dry summer (Mediterranean climate). At the present time it is somewhat used as breadstuff in Scandinavia, Russia, Germany, and southeastern Europe. Its use in countries with high standards of living is chiefly confined to stock feed and the making of malt for beer, for which it is extensively used in Europe.

The large yield makes barley a substitute for corn as a food for hogs, horses, and cattle in countries that cannot grow sufficient corn, such as Canada, where its acreage more than doubled since World War I, Europe north of the Alps, and the Pacific slope of the United States. In Great Britain and Germany it occupies about three-fourths as much



Comparison of the barley map with the oats map shows that these two grains are not on friendly terms except to a small extent in Minnesota and Wisconsin, but barley is of increasing use in Virginia in the Chesapeake drainage area.

of the crop land as wheat, and to a considerable extent takes the same place in farm economy that corn does in the American Corn Belt. Its close approach to corn in yield makes it a real rival. If we should some day have a new sense of patriotism and realize that a gullied cornfield is a partial destruction of the United States—then our barley crop will boom. A dairy farmer in Virginia (lat. 39° N., alt. 500 ft.) harvests annually, from the same field, a barley crop in June and a soybean crop in September, and does it year after year.

Importance in Arid and Cooler Lands. The drought-resisting quality makes barley important in arid lands, such as those around the Mediterranean Sea, Asia Minor, central Asia, Australia, and California, where it will grow nearer to the desert than wheat. In countries having a winter rain and summer drought kind of climate, such as Australia and California, the barley is often made into hay by being cut before the grain is mature. At this time the entire plant makes good forage. In California, the barley crop of 44 million bushels in 1942 was four times that of wheat, which it is rapidly replacing as a market grain, probably because of superior drought-resisting quality—a factor of great importance in a state with so much arid land. In the Great Valley barley produces a larger average return per acre than either wheat or oats. Most of this California barley is used as corn is in Iowa—for horse, cattle or hog feed. As in summer-dry California, so it is important in Spain and Algeria.

The most important barley region in America reaches from Chicago northwestward through Minneapolis up into Canada, and corresponds roughly with the spring wheat belt, but it also includes Wisconsin, and part of northern Iowa. In 1943 North Dakota, South Dakota, Minnesota, and California produced half of our barley crop of 322 million bushels.

The fact that barley ripens earlier than wheat is a factor of very great importance because the two crops, one food for man, the other feed for beast, do not compete for the growers' time at harvest, so that he can grow more acres of the two grains than he could of either alone. The superiority of corn as a forage plant in the United States has limited the total growth of barley in this country. Europe produces about one billion bushels, nearly one-third being grown in Russia, which was the chief prewar barley exporter. Little Denmark with her many cattle grows over six times as much barley as wheat. Its recent growth in Kansas for hog feed suggests its substitution for corn on the arid edge of the Corn Belt, but it must compete with kafir corn south of Nebraska.

The heavy yield of barley causes the Japanese to use it on lands not suited to rice, and the crop is about one-seventh as great as the rice crop and about 50% greater than the wheat crop.

5. *Buckwheat*

Buckwheat, an unimportant cereal, is among grains as the goat is among animals—conspicuous for its ability to nourish itself where the supply of nourishment is meager. This feeding habit of the plant, enabling it to live on the poorer and rougher lands, in combination with its very short period of growth, makes it the cereal best fitted

for growth under the worst conditions of cold countries. These characteristics also make it a soil exhauster. It grows so quickly that it can be sown in midsummer in eastern United States after other crops have failed, or have been harvested, and yet ripen before frost. Its qualities combine to make it a crop for farms of rough and mountainous localities, such as the upper part of the Appalachian Plateau in New York and Pennsylvania, parts of New England and Canada, the mountainous districts of France, the Alps, and Russia. The excellence of the buckwheat flour for making batter cakes makes it a favorite article of diet where buckwheat is known. Persons who keep bees for the large-scale production of honey sometimes grow buckwheat because of the large amount of honey in the flowers, thus getting a double harvest. New York and Pennsylvania produce about two-thirds of the total crop of the United States, which amounts to about less than 1% of the wheat crop.

6. *Millet and Sorghum*

Millet is supposed to be the oldest of the cereals in man's dietary. Its use in China is older than history, and it is today the mainstay of millions in that hungry land, but we Americans have much difficulty in appreciating its importance as a cereal. We do not use it as a cereal. It is a plant not unlike corn or sugar cane in general appearance, with its seed in a head somewhat like that of the cat-tail. In the Far East, the grain, which is smaller than wheat grains, is boiled and used like rice, or eaten parched or made into meal and porridge. There are many varieties, some a dozen feet in height. Some are grown for forage only, some for the grain to be used as human food, some for both purposes, some varieties furnish fuel in their woody stalks.

Millet is grown to some extent in most parts of the temperate zone and also in the tropics. It is grown occasionally in nearly all parts of the United States for forage only, but the excellence of corn in the east and south and of alfalfa in the west keeps it from having any wide use in this country, save in the Kansas-Oklahoma-Texas part of the eastern Great Plains where it is coming to the front as a forage plant. It has a similar use as forage in Europe, being extensively grown in the Mediterranean region and Russia. It is used as food to a slight extent in Europe and among the natives of Mexico and Africa, but it is in Asia that millet reaches its greatest importance. Japan is credited with an annual consumption of 10 million bushels. Millet is the staple food grain of parts of India, where the acreage is estimated to be about 18 million while the wheat crop covers 34 million acres. The accounts of the Russo-Japanese War showed that many of the campaigns (Manchuria) were waged in fields of millet and Indian corn, which resemble each other very much as they stand in autumn shocked in the fields.[16] Millet

[16] E. R. Scidmore in *National Geographic Magazine*, April, 1910, says that a giant millet 10 or 12 feet high, along with a short millet and sorghum, is extensively grown in Manchuria. The giant millet looks like corn shocks in Indiana and "is used for food, fuel, distilled drink, mats for the floor, and for building material, and has thousands of uses and the yield a thousand fold."

These drought resisters, millet and sorghum, are important factors in the recent advance of Chinese emigrants to the north and northwest.

seems to have been very important to the prehistoric lake dwellers of Switzerland.

The sorghum family is another cereal producer little known in the United States but important in many parts of the world. To this family belongs the well-known broom corn from which brooms are made, the Kafir corn of South Africa, and the sugar-producing sorghum. They are tall plants with general resemblance to millet in appearance, excepting a difference in the form of seed-bearing head. In uses they are substitutes for both millet and corn. In China, India, and Africa their use as forage is very great and their use as human food is also very common, while some of the many varieties are cultivated for human food in nearly all the warmer countries of the world. A member of this family is durra, the oft-mentioned food grain of many African tribes.[17] Drought-resisting sorghums have sprung into prominence as forage plants in the drier parts of the United States.

Importations of seed from dry areas in East Asia and South Africa have resulted in a rapid increase of the growth of grain sorghums for forage, grain, and silage. The center of this production is the plains of Kansas, Oklahoma, and Texas, with South Dakota as a substantial producer. The acreage, 16 million in 1943, nearly doubled between 1929 and 1943, and it is about the same as the total crop acreage of all crops in Japan—a good measure of Japanese poverty.

[17] A. Reuter's dispatch from Wad Menadi, Blue Nile, discusses the effect of rain on "durra, which forms the staple food of the native population." To millions in Africa, who cook it as mush or cake, it is the staff of life.

. . . 16

The Vegetable and Fruit Industries

1. *Vegetable Production and Trade*

Vegetables and Garden Products. Nearly every farm has a vegetable garden, and some plants are cultivated and eaten by almost every people. Owing to the large yield of a small plot of ground under intensive care such gardens are very common in villages and small towns of both Europe and America. During the years of World War II, when food shortages were common, many a denizen of town and city took a new job and planted and worked the soil of his back yard in order to provide fresh vegetables for the family table.

The commercial truck gardens of Europe and America contain a large variety of plants that represent in their origin every continent and almost every country in the world. In many cases they have been cultivated until they bear little resemblance to their original form, and in our list of vegetables is found in edible form every part of a plant—roots, stems, leaf stalks, leaves, blossoms, pods, seeds, fruit.

The Commerce in Vegetables. Although most of the world's supply of fresh vegetables is still produced near the market, the development of refrigeration and cheap high-speed transportation has greatly increased the volume and radius of trade in these bulky and perishable foods. The perfection and increased use of the refrigerator ship, the refrigerated railway car and motor truck, and terminal storage facilities with scientific automatic temperature control now permit the continuous sale of fresh vegetables and fruits in the urban markets of Europe and America. Indeed, this traffic is now so important that sometimes a passenger train filled with wealthy northerners bound for the playgrounds of Florida has to take a siding while an express train loaded with plebeian cabbage, lettuce, and tomatoes rushes north to help feed those who must remain at home.

For some years the American diet has been shifting somewhat from a bread, meat, and potato basis to one of cereals, fruits, and vegetables. We ride in automobiles, busses, and subways. We push buttons and pull levers. We save energy and need less food. Each year our per capita consumption of fresh vegetables, rich in minerals and vitamins, continues to increase.[1]

In the United Kingdom alone the importation of vegetables in 1938 was worth about $65,000,000, chiefly pota-

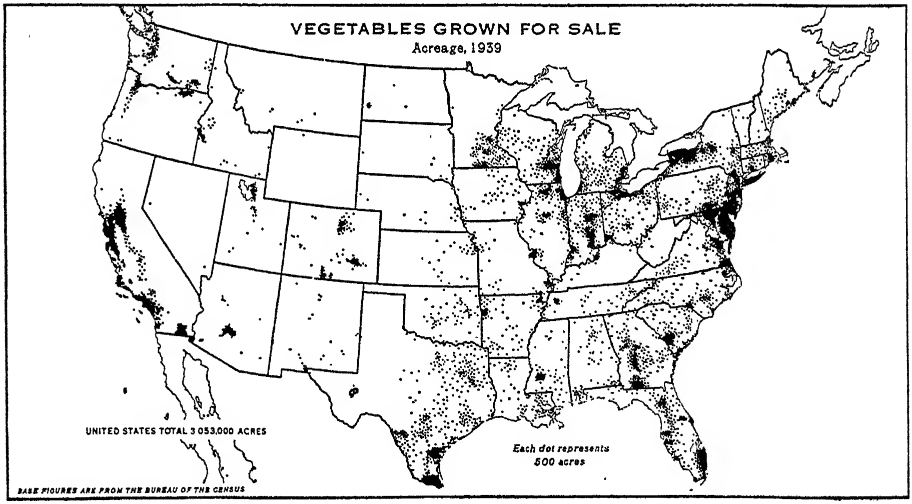
[1] Between 1918 and 1943 the per capita consumption of tomatoes in the United States increased from 24.6 to 30.2 lbs.; melons, from 26.1 to 30.8 lbs.; leafy, green, and yellow vegetables (asparagus, lima beans, snapbeans, cabbage, carrots, kale, lettuce, spinach, etc.), from 69.7 to 89.2 lbs.; other fresh vegetables (artichokes, beets, cauliflower, celery, sweet corn, eggplants, onions, etc.), from 69.2 to 85.2 lbs. On the other hand, the per capita consumption of white potatoes, a great starch food that adds to milady's corpulence (and my own), has decreased from 173 to 130 lbs.—U. S. Dept. of Agriculture, *Agricultural Statistics, 1944,* Washington, 1944, p. 240.

toes, onions and tomatoes. In addition to this there is a lively local trade between south and southwest England, the warm channel islands and Cornwall and the colder parts of Great Britain.

Daily steamers now take large quantities of garden stuffs, grapes, small fruit, and flowers to British cities. Most of the vegetables imported into Britain come from the south of France, Spain, Italy, North Africa, and the Canary Islands. When business is normal, Europe north of the Alps receives large quantities of these southern products that are grown so easily in the sunny Mediterranean countries, while frost prevails in the colder north. France has a large traffic in early vegetables from her colony of Algeria, sheltered from the cold north winds by the warm waters of the Mediterranean. Egypt's sunny climate becomes of value to her through the export of 200,000 tons of early onions between March and May to Liverpool, London, Hull, Hamburg, Trieste, and occasionally to the United States.

Resemblance of Flower and Vegetable Industry. The French have a flower industry so closely akin to vegetable growing in its economic and climatic aspects that it should be mentioned here. Every night during the winter months the "Cut Flower Limited Express" picks up carloads of flowers between Nice and Toulon for delivery in carloads to Paris, Frankfort-on-the-Main, Munich, Berlin, Vienna, Leningrad, and to London and Manchester, via Calais. Even more remarkable is the "Orchid Express," involving the regular delivery by airplane of these jungle flowers from the far-distant Netherlands East Indies to be sold to wealthy people in the leading cities of northern Europe.

Vegetable Production on the Atlantic Plain. Our Atlantic Plain is a nearly level area lying between the Atlantic Ocean and the first stratum of hard



This map is a fine illustration of the tendency of the vegetable crops to develop localized production, which has many advantages in both growing and marketing. West of the 100th meridian, they are nearly all in irrigated valleys.

rock that limits the sands and clays of the plain and causes in the rivers crossing it a series of waterfalls extending in a nearly straight line from New York southwestward through the cities of Trenton, Philadelphia, Baltimore, Washington, Richmond, Raleigh, N. C., Camden and Columbia, S. C., and Macon and Columbus, Ga. This plain, largely composed of sandy soil, is not fertile but can be made highly productive through the application of fertilizer. Much of the plain is therefore in second- or third-growth pine forests which can grow in sand. Fortunately, however, this sandy soil suffices for the growth of peas, melons, cabbages, strawberries, etc., which are composed very largely of water, and which have a much earlier planting and harvest-time on light sandy soil than on heavy clay soil, which does not dry or warm so quickly as sand. Thus the Atlantic Plain has an advantage over the Piedmont and Appalachian districts lying to the west, with their fertile but heavy clays.

The possibilities of sandy soils for garden products are shown by the practice of some New Jersey growers who harvest on the same field a pea crop June 1, a cantaloupe crop August 15, and turnips in October, and at the same time have the land well set in crimson clover, or vetch, legumes which gather nitrogen, make humus, and are plowed under the next April or May, when nearly knee-high and full of scarlet or lavender blossoms. Another New Jersey truck combination is Canada peas picked in May and June, followed by a crop of corn with a legume side crop of vetch, cow peas, or crimson clover—to fertilize the earth. These are not average practices but they might easily become so. They are the exceptions where intelligent and industrious men show the possibilities of a land much of which is little used.

From this sandy Atlantic Plain there comes throughout the cooler part of the year a procession of vegetable products that follows the advance of the seasons.

When October's breath of winter turns the fields of New Jersey and Long Island brown, the huckster and the groceryman of the northern city begin to sell beans, lettuce, eggplants, and cucumbers from southern sands, and at Christmas come Florida strawberries which New Jersey can produce only in May and June. The Florida truck farmer often has a rapid rotation of crops. A skilled farmer ships heads of lettuce in January, the ground is immediately set to tomato plants from which the crop is shipped in March, then potatoes are planted for shipment in May, while, through the summer, the velvet bean, a rapidly growing legume of the tropics, makes food for his mules and leaves nitrogen in the soil for the crops of the succeeding winter.

As the spring advances northward so does the location of the truck harvest. Next after the supplies of south Florida come those of north Florida, then those from Savannah, Ga., then Charleston, S. C., districts including the nearby islands have their turn, followed by New Bern and Wilmington in eastern North Carolina, while Norfolk, Va., with steamboats running to Washington, Baltimore, Philadelphia, New York, and Boston is one of the greatest truck centers in the United States. This port ships enormous quantities of early potatoes and strawberries to the northern cities, to be followed in its turn by

the peninsula between the Chesapeake Bay and the sea known as the "Eastern Shore," which, with its ramification of navigable bays and estuaries, with railroads on the land, has one of the finest systems of transportation and is one of the finest agricultural districts of the United States. In early June potatoes are grown here and sold by an efficient cooperative association in all parts of the country and Canada. Lastly come the heavy shipments of truck crops from the fields of southern and eastern New Jersey, Long Island, and the smaller areas near the New England manufacturing cities.

The bulky nature of products of this class gives a great advantage to the producer who can haul the crop to market in his own motor truck. Hence there is a much greater concentration of production near the larger cities.

A Business with the Gambler's Chance. The price of the vegetables varies from season to season, indicating that the business is uncertain and, as shown by the extent of the variation, a perilous one. The earliest products on the market bring the best returns, so the truck grower always aims to be as early as he can and therefore is in constant danger from the frost, of which the cold waves always hold possible store. A promising harvest may be blackened by frost in a single night, or spotted by fungus encouraged by one or two muggy days, or a severe January freeze may cost Florida millions of dollars. Rains and cool weather in one section at times retard the development of the plants, causing the product of two or three great centers to mature at one time and produce more than the market demands, so that the price goes down to the point where the shipments will not pay the freight. This is even more common than frost. Indeed it is this lack of profits, this loss because of oversupplied markets, that checks the development of the industry. The coast plain has many times as much land as is needed for truck, and the ever-recurring losses stop the indefinite expansion of the industry.

The Vegetable Industry of Mississippi Valley. Chicago, St. Louis, and other cities in the central part of our country draw off-season supplies partly from certain sandy districts in Tennessee, Mississippi, Louisiana, northwestern Texas and from the irrigated lands of the Lower Rio Grande Valley of Texas. The parade of south Texas vegetables to northern markets occurs in well-defined seasons. Early potatoes are shipped to market from December to March, cabbages in February, March, and April, and tomatoes in May and June. More than 50 different crops are grown in this valley alone, which normally ships about 25,000 carloads of fresh vegetables to northern markets every year. Within the valley are distinct centers of specialization, Crystal City, Tex., claiming to be the largest spinach-producing center in the world, with a monument, a bronze monument if you please, to a hero named Popeye. It stands in Popeye Park.

The California Vegetable Industry. The open winter of California gives that state an important vegetable industry which probably reaches its highest development on the reclaimed delta lands ("tules") at the mouths of the San Joaquin and Sacramento rivers. These deltas are especially fine for the production of asparagus, which is grown

in vast fields, shipped fresh to eastern markets, and is also canned. Each year about 50,000 carloads of vegetables are shipped by rail to eastern markets despite the handicap of long distances and high freight rates. Distance is less of a deterrent to the transportation of dry edible beans which are concentrated and non-perishable. The California output in 1943 was 5,000,000 bags of 100 pounds each, most of the crop being raised on the semi-arid lands near the sea in the southern part of the state.

In recent years southern California has encountered increasing competition from other sections of the West. For example, lettuce is produced and shipped in large quantities to the East from the White River Valley of Washington, the irrigated lands of the Salt River Valley of Arizona, as well as from the Salinas Valley of California. The high mountain valleys of Colorado and New Mexico ship midsummer lettuce which thrives in the coolness of elevation.

American Foreign Trade in Vegetables. Imports of fresh vegetables into the United States are small in comparison with our huge production and domestic trade. Chief sources of vegetable imports are Cuba and Mexico, which have the advantage of a warm climate, low labor costs, and proximity to the American market. Most of the Cuban production is centered around Havana which has good steamship connections with American ports, while most Mexican exports are shipped by rail from irrigated lands along the shores of the Gulf of California. Each year early vegetables from Cuba and Mexico arrive on the American market just ahead of the Florida and Texas crops. From these two countries we import about 70,000 tons of tomatoes, 7,500 tons of green peppers, and 3,800 tons of eggplant annually, together with minor shipments of green peas, lima beans, potatoes, okra, and other vegetables. Our onion imports, varying from 25,000 to 100,000 bushels a year, come chiefly from Italy and Chile, occasionally from Egypt.

From our northern neighbor, Canada, we import 650,000 to 1,200,000 bushels of seed potatoes annually. These potatoes, like those of Aroostook County, Maine, and grown in nearby parts of Canada, are highly prized by our southern farmers, because seed potatoes grown in cooler climates are more hardy and mature more rapidly than those produced in the South. It seems that plants learn to take it easy when they can. Since vegetable production begins in Canada later than in the United States, Canada imports from us about 800,000 bushels of early potatoes every year, together with smaller shipments of onions and other vegetables.

Although canned vegetables dominate the American export trade, considerable quantities of potatoes, dried peas and beans, and onions are shipped each year to Latin American and other foreign markets.

Garden Seed. The production of garden seeds is a part of the vegetable industry well suited to isolated or distant locations where the marketing of the fresh product is difficult. The American onion crop is grown largely from seed produced in California and the Canary Islands, where an important onion seed industry has sprung up in the isle of Teneriffe. The cantaloupe crop of the Atlantic Plain is in large part grown from Colorado seed. In western Kansas and Nebraska enormous crops of water-

melons and squashes are fed to the farm animals, which are the chief product of that region, after the seed has been saved for the planters of localities more favorably situated to ship carloads of melons or squashes. For some years most of the nation's supply of cabbage seed has come from Skagit and King counties, Wash., along Puget Sound. Since garden seed is of high value in proportion to bulk, it can easily stand transportation charges on long hauls to market.

2. *Peas and Beans* (*Pulse*)

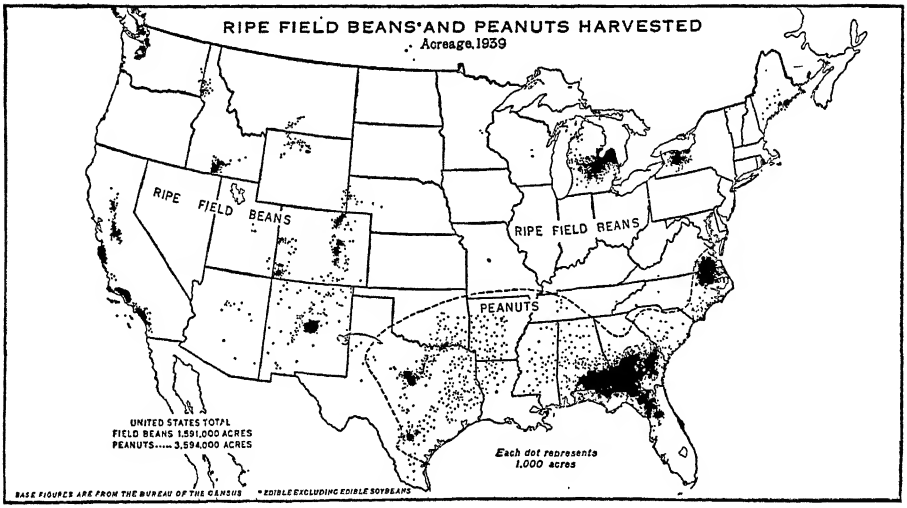
The Nitrogen-producing Legumes or Pulse. The most important of all vegetables is the group of legumes comprising the many kinds of peas and beans, which are called pulse in the Old World. These differ from all other vegetables in the large amount of protein or nitrogenous food, meat substitutes, which they contain (see Table 22). Nitrogen, as food for man, beast, or plant, is expensive to buy, yet over three-fourths of the air is nitrogen, which, owing to its chemical inertness, is hard to obtain in available forms. Hence its high cost. The legumes have the ability, great for the present, and greater for the future, of producing upon their roots nodules which are colonies of the microscopic plants called bacteria. These organisms catch nitrogen freely from the air and thus enable the legumes upon which they live to render to mankind a service of incalculable value by giving nitrogenous food for man, beast, or plant. By the aid of these bacteria the legumes can grow in poor soil and leave it the richer in nitrogen because of the nodules on the roots that remain in the ground. Experiments have even shown that non-legumes growing beside living legumes are richer in nitrogen content than similar plants not so placed.

The pulse plants are represented chiefly by peas and beans. Peas are grown largely in the relatively cool parts

The velvet bean, a swift-growing legume, has here climbed to the top of the cornstalks in Arlington County, Virginia, near Washington. This is a wonderful combination of nitrogenous and carbohydrate forage, also a soil improver.

of the temperate zone, but beans are produced under diverse climatic conditions, much of the world's bean export trade originating in tropical and subtropical lands. Peas and beans are of less use in the United States than in any other large country, because Americans get their nitrogenous food in the more expensive forms of meat, cheese, and milk.

In the United Kingdom, before the potato was introduced and a world trade in meat established, pulse plants were more important than they are, but



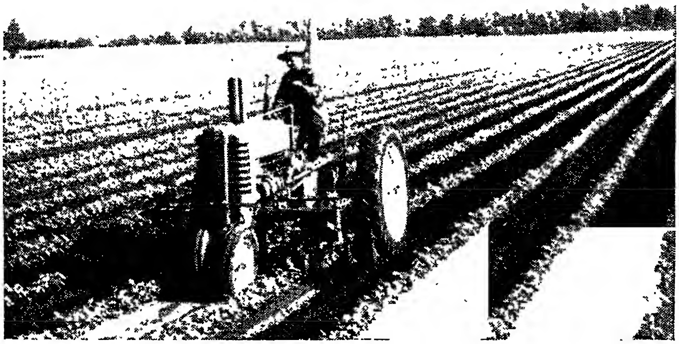
Boston is famed for baked beans, but Massachusetts gets them from New York state, Michigan, Colorado, and New Mexico. California dried beans are mostly lima beans. The Virginia and Carolina peanuts are the ones that we eat. Those in Georgia and Alabama are the ones the pigs root up and eat and the ones that go to make oil.

there are about 275,000 acres of them grown each year and thousands of tons of peas and beans are imported; the former, chiefly from Canada, much of the latter from Manchuria, Burma, and Madagascar.

Importance of Pulse to Poor Peoples. In the Mediterranean countries the pulse plants are much more important than among the richer peoples of north Europe. The lower wages of the Spaniards and Italians make it impossible for them to buy meat from abroad, as do the British, and the dense population combined with the lack of grass make impossible the rearing of adequate numbers of meat animals per capita. To get their nitrogenous food the Spaniards, Italians, and other people of the Mediterranean turn therefore to the cheaper forms of peas and beans. The gram or chick pea is one of the chief items of diet in Spain, and is also greatly used by the peoples of Morocco, Algeria, and Tunis, whence it is carried by caravans into the desert in exchange for dates. With this, as with other staples of food, the western European supply is insufficient. Spain imports them from Mexico, England imports them especially for making soup, while France gets thousands of tons per year from northern India. Lentils, vetch, and lupine, other pod-bearing pulse plants somewhat like our peas and beans, are much grown throughout all Mediterranean countries, and from the Isle of Cyprus there is considerable export of the long, flat, sugary pods of the carob tree, a legume sometimes called locusts.[2]

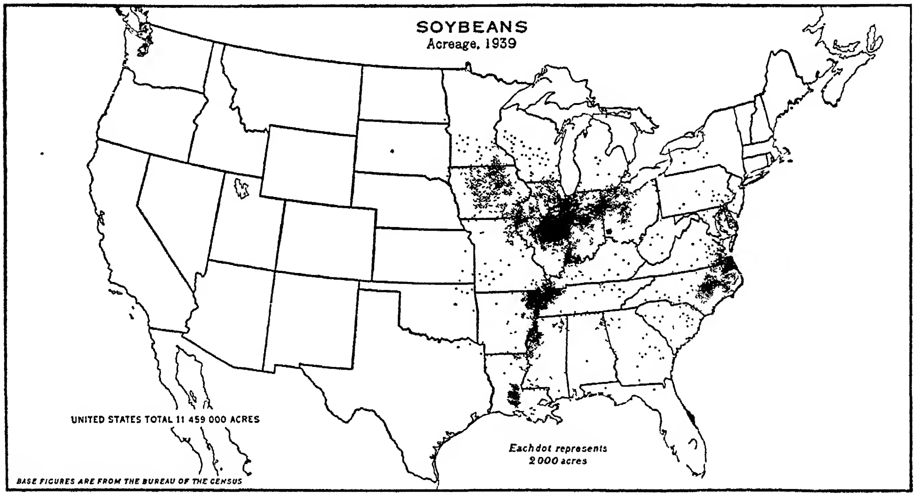
As the people of the United States are more able than those of England to buy

[2] Locusts are widely used as a substitute for oats in horse feeding. Locusts are sometimes called St. John's Bread, as they are said to have been the food of John the Baptist in the Wilderness. If so, his food was not so bad.



A

The soybean, after millenniums of service to the peoples of east Asia, is here having a new experience—being cultivated by a tractor, two rows at a time, on the flat, black soils of our Corn Belt.



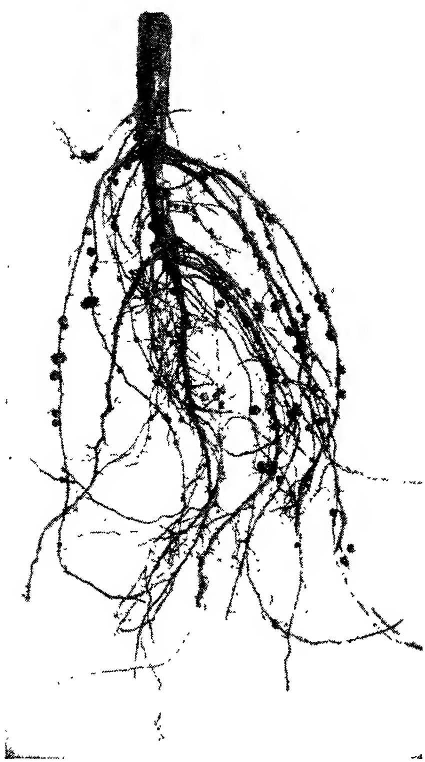
B

More than any new crop, the soybean is rising almost like a rocket in its place in American agriculture and it has increased greatly since 1939. It seems to be equally at home in the Corn Belt and the Cotton Belt. It promises to have almost as great a future as in its old home in the Orient, where it is said to be eaten in 400 different forms.

meat, they use less pulse, and as the people of England are richer than the peoples of the Mediterranean and use less pulse, so are the peoples of the Mediterranean richer than the hordes who occupy southeastern Asia. To the latter, accordingly, foods of the pulse family are an absolutely indispensable article of diet. Rice, substitute for bread and potatoes, is deficient in nitrogen, but peas and beans are grown throughout these countries to supply this need. In India,

the chief dependence is the lablab pea, the product of a climbing vine, eaten by both man and beast.

In Manchuria, China, and Japan the chief dependence is the soybean, a nu-



Roots of nitrogenous nodules of soybean plant reduced to ⅓ in size. It is one of the few perfect protein foods for humans and also a gatherer of nitrogen for the crop that follows.

tritious legume with three times as much protein as wheat. It is a summer crop and is a remarkable drought resister. There are several hundred varieties of the soybean and it comes in many colors, including green, black, brown, all the colors in between, and almost all the shades of yellow. This great food plant, which has undoubtedly seen several thousand years of service, is used in all the forms in which we use beans, and oil is extracted from the beans to take the place of butter. Even more surprising is the soybean milk, made by slightly fermenting the meal in water. This milk is used for many of the purposes that we use cow's milk, even including the precipitation of the curds and the manufacture of cheeses widely used in China. The beans are crushed between heavy rollers to extract the oil, leaving a cake or meal that has, for centuries, gone in junks to Japan for feeding cattle and use as a fertilizer.

In Europe and the United States, as the result of improved extraction, a bushel of beans generally yields about 8½ pounds or more than a gallon of oil and from 45 to 50 pounds of meal. In this country more than 95% of all soybean meal is used for feeding livestock and poultry, but some meal is ground into flour for use in breakfast food, crackers, malted milk, baby food, and other products. Increasing quantities of soybean oil are entering the manufacture of margarine, cooking oils, printing ink, linoleum, paint, varnish, enamel, soap, glycerine, and plastics.[3]

About three-fourths of the world's crop of 478,000,000 bushels in 1939 was produced in China and Manchuria, large quantities of beans and oil being exported to northwestern Europe and Japan. Between 1939 and 1943 production in the United States increased from 91,000,000 to 196,000,000 bushels, much

[3] See Joseph A. Russell, "Synthetic Products and the Use of Soy Beans," *Econ. Geog.*, vol. 18, January, 1942, pp. 29-40.

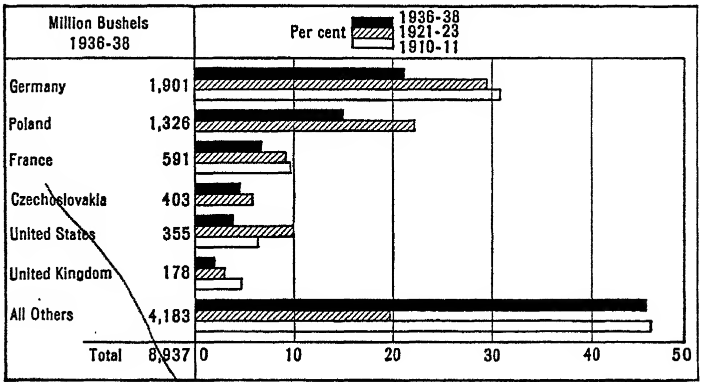
of the increase occurring on Corn Belt land that was released from oat production by our declining use of horses and mules. The soybean boom in American agriculture seems here to stay. There is even a journal, *Soy Bean Digest.*

3. *The White Potato*

The Human Engine. An engine needs fuel. The human body may be likened to an engine. It is built largely by the food element protein, furnished by milk, meat, cheese, eggs, most of the nuts, and the leguminous plants, of which peas and beans are the best and commonest examples. Protein, the tissue or muscle-maker, is contained to some extent in all the grains, from wheat, the richest in protein, to rice, the poorest. Fuel for our human engine is furnished by the carbohydrate group of foods.

Starch, one of the two most universal food elements of all mankind, is classed as a carbohydrate—an energy food. It helps to make fat and heat to keep the body warm and gives energy for work. Starch is really the surplus nutrition which the plants store within themselves for future needs or for their offspring. Sometimes it is packed in the seeds, as in the grains; or the roots, as in sweet potatoes; or in the peculiar underground stem, as in the white potatoes; or even in the trunks of some of the trees, as in the sago palm. The grains, by containing both the great food principles, are almost perfect food, save for the needed roughage and vitamins of leaf greens. As rice is the richest in starch, there is less need for the production of other starch-producing plants by rice-using peoples. In the United States, we get most of our starch food from cereals and potatoes.

Distribution and Use of the Potato. The potato is probably exceeded only by bread in the number of times per year it is eaten by the average resident of central and northern Europe, and also central and northern United States. The plant is a native of America, growing wild on Mexican, Bolivian and Peruvian plateaus, whence it was taken



The graph of potato production on the three-year averages shows that a rich country like the United States really does not have to bother with them much, but in the agriculture of cornless countries like Poland and Germany, the potato almost takes the place that corn does in the United States, in addition to being a greater food dependence for the people.

The tractor draws a machine which scoops up the earth under two rows of potatoes, sifts out the earth and drops the potatoes in rows on top of the ground ready to be picked up.

to Spain, to Italy and to Vienna. From Vienna (1598) it spread rapidly through Germany. Introduced into Ireland in 1586 by Sir Walter Raleigh, it soon became important. By 1760 potato growing was general in Scotland, and its growth to some extent is common in all Caucasian lands. It appears occasionally even in Africa, but was not introduced into China till about 1875. In the rice-growing parts of this empire the potato is held in contempt, but in the mountainous and northern parts it is diligently grown and with much pride. Its esteem is increasing. The potato has certainly established itself as a great cool climate starch food. It is probably the plant most commonly grown in the vegetable gardens of Europe and America; but its growth as a money crop is quite restricted, offering in this respect a marked contrast to wheat. The potato and rice are rivals in the supplying of starch upon the tables of Europe and America, but the two plants are rarely rival claimants for the same farmer's attention. The recently rediscovered art of making potato flour has given the otherwise perishable tuber a new means of competing with rice, but thus far the flour has not met with very wide use outside of Germany where it was first manufactured.

Qualifications of a Potato Country. The potato is a crop of wide climatic range. Cold Alaska as far north as Fairbanks produces regularly, and in 1929 had a crop of 41,887 bushels from 388 acres, and they are cultivated in the subtropics, as in Florida and Egypt. The potato tolerates a variety of soils. It grows well on land that does well in wheat or corn, but tends to become important as a main starch food for people and a money crop for farmers in regions where it is too cool for corn to grow to the best advantage, or where the soil is too sandy and light for the large yields of small grains.[4] It does not do well on heavy clay. The regions that meet

[4] The comparison of the Department of Agriculture map of dairy products with that of potatoes shows in central Wisconsin a dairy vacancy and a potato concentration at the same place that soil maps show a wide stretch of sandy soils.

Frequent spraying with poisonous liquids or dust is necessary to protect the potato plant from fungus and insect enemies if the plant is to do its maximum of work at storing starch underground.

crop for the farm and food for people than any other country in Europe. So great was this dependence that in 1846 a failure of the potato crop, due to a blight, was followed by famine from which thousands of people died. In 1924 a wet summer in west Ireland repeated this same performance in miniature, and the call for help went out to foreign lands. Scotland, with agricultural resources like those of Ireland, but much more meager, also has potatoes as an important crop. The isle of Jersey in the Channel Islands is almost one large potato field. The plain of north Europe, reaching from the northwest point of France through Holland and Belgium, Germany, Poland, and Russia to the Ural Mountains has in many places a sandy soil and is the seat of the greatest potato-growing region in the world. The potato is important to the French. With less than a third our population they grow 50% more potatoes than we do, the French crop averaging 573 million bushels in 1935-39. The Dutch and Belgians make their small countries produce a surprising amount of potatoes The production in Belgium is about 15 bushels per capita, while the United States produces only 3 bushels per capita or less.

Germany with her cool sandy northern plains finds the potato one of the best crops she can grow. For years she was the greatest potato-producing country in the world,[5] although since 1925 her output has been exceeded by that of Russia. About one-fifth of the German potato crop is devoted to the manufacture of alcohol, much of it being used as motor fuel, and large quantities of potatoes are also used in the manufacture of starch. In Russia, which leads the world with an annual crop of more than 2 billion bushels, potato production is widely distributed, the heaviest centers of production being located on the sandy plain between Moscow and the Polish border.

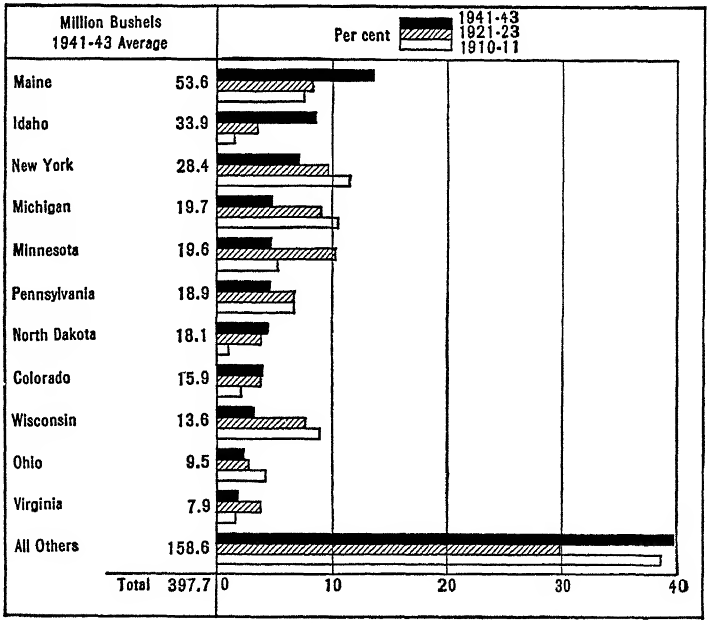
Great Britain, France, Germany, Belgium, Austria, Czechoslovakia, and

[5] The stupendous potato crop of Germany, which, after all, covers but little more ground than Maryland, gives cause for the interesting statement of Professor S. N. Patten that it was the potato that enabled Germany in 1870 to overthrow France, long her superior, in the days when wheat was a more exclusive basis of man's support than it has been since.

Switzerland must import potatoes in order to meet domestic demands. Little Holland is the world's greatest potato exporter, shipping about 15 million bushels a year. Large quantities of Dutch, Spanish, Polish, Italian, Hungarian, and North African potatoes are delivered every year to the great urban markets of western and central Europe.

The Potato in the United States. Owing to the average American's ability to raise corn and to buy higher priced foods, the potato is less sought as food in America than it is in Europe. The chief centers of its growth lie north and east of the Corn Belt. The graph (Fig. 477) showing the production in the eleven leading states reveals how distinctly the potato separates itself from the corn crop, only two major corn states, Ohio and Minnesota, being in the list. The potato is grown to a great extent as a money crop in certain sandy areas in Minnesota, Wisconsin, Michigan, and also in parts of Pennsylvania, New York, and New England, especially Maine. In the adjacent and similar parts of Canada it is of even greater relative importance, Prince Edward Island, cool, loamy and Scotch, having the astonishing figure of 72 bushels per capita.

The growing of potatoes as a money crop tends to become very much concentrated in certain districts. In Aroostook County, in the St. Johns River Valley in northern Maine, agriculture, which had greatly declined, suddenly



Graph of state production of potatoes, by three-year averages over a thirty-year period, shows that Maine and Idaho have gained heavily at the expense of every other state, except North Dakota, which gained a little, and Colorado, which has held its own. Apparently market milk and cheese and butter have won out in New York, Pennsylvania, Minnesota, Michigan and Wisconsin.

revived through the rapid rise of potatoes as a commercial crop for that district. Similarly, Monmouth County, New Jersey, between New York and Philadelphia, has become a potato center, shipping in a single season more potatoes than the whole state of Massachusetts produces. The sandy soil of the Atlantic Plain from the east end of Long Island to Florida is much of it better suited to potatoes than to grain crops; and on eastern Long Island, as in the only two counties of Virginia that lie east of the Chesapeake, the shipments of potatoes have within the last few decades made the farmers very prosperous. These specialized centers have become so in part because of cooperative marketing organizations. These organizations stimulate production by improving technique, for example, certified seed, and also by cooperative marketing.

TABLE 24

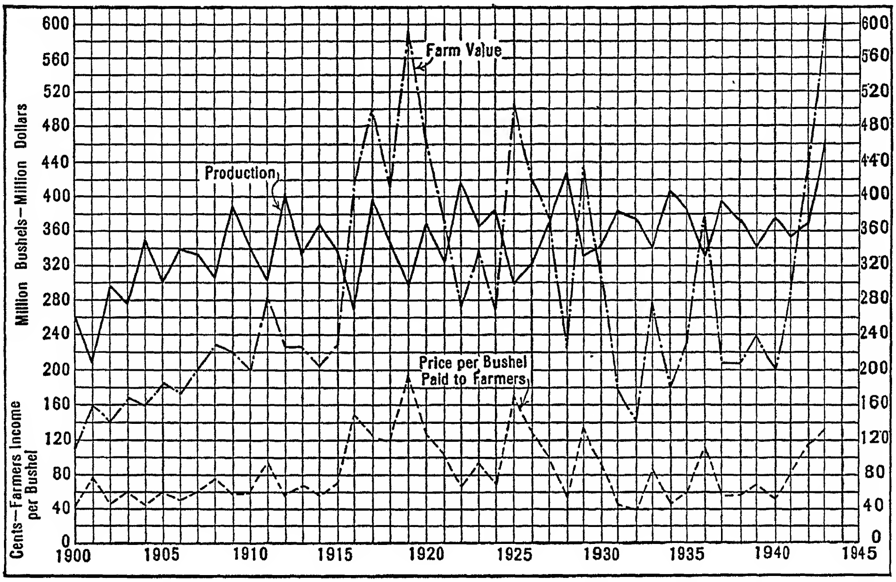
UNITED STATES PRODUCTION OF POTATOES

	Acres planted, 1,000 bu.	*Yield per acre, bu.*	*Production, 1,000 bu.*	*Season average price for farmer, cents*	*Exports, 1,000 bu.*	*Imports, 1,000 bu.*
1918	.....	96.2	346,114	118.8	3,689	3,534
1923	.....	108.5	366,356	92.5	3,075	564
1929	3,041	110.0	332,204	131.6	2,386	6,006
1934	3,760	112.9	406,105	44.6	1,218	532
1939	3,056	120.3	363,159	69.6	2,518	1,874
1943	3,430	139.9	464,656	131.1	.....	.....

Source: U. S. Dept. of Agriculture, *Agricultural Statistics, 1944,* Washington, 1944, p. 225.

The Potato in Foreign Trade. On account of the great bulk and weight of potatoes in proportion to value, and because of their perishable nature, they are much less important in international trade than in home production. As a whole, they have a tendency to become a national supply crop, with commerce limited to emergencies and early supplies. When, as occasionally happens, we have a shortage in this country, they come to us by the hundreds of thousands and even millions of bushels from Canada, Ireland, Scotland, Germany, and Egypt. In normal years our potato exports exceed imports. About one-third of our exports are destined for Canada, where they arrive before local production has begun, and in most years we ship potatoes to Cuba, Mexico, and other Caribbean countries, where the warm climate makes their growth unsatisfactory,[6] and where a part of the

[6] The potato varieties now in cultivation are from the wild potato of cool plateaus in South America. Those in low-lying tropic lands have thus far been neglected, one of the almost innumerable avenues by which agriculture might be enriched by crop creation—a line of work at which we might do so much and are doing so little.



The potato and the revolution! The oscillating line of potato production and the oscillating line of farm value of the crop to the farmers shows a remarkably inverse relationship. In times of peace almost every enlargement of the crop has meant reduction in the total value of the crop. You can observe it year after year. The war years should not be considered because the industrial system is disturbed. This graph shows why it is that a limitation of production has become such a widespread ideal and such an actively sought policy by producers in the area where supply and demand are supposed to function. "Free Enterprise." What is it? (Data from *Agricultural Statistics, 1942,* p. 383; *1944,* p. 225.)

population has a taste for this northern form of starch supply. When considered in relation to the total bushels produced, the figures of our foreign trade in potatoes are conspicuous for their smallness and for the irregularity of the amounts.[7] In normal years Cuba is our customer for about half of them.

Potato production is limited by the home market and not at all by the land possibilities. Our 4,700 square miles in potato fields are an insignificant patch. A large crop gluts the market, and actual overproduction or the fear of overproduction and the consequent low price is the limiting factor in potato production. The price to the grower fluctuates between five cents and three dollars a bushel, between absolute loss and large profits. The existing farms and men and equipment of America could, if assured a price of a cent and a half a pound, easily double the potato crop without producing any corresponding lessening of other crops, and there is abundant room to grow ten or twenty times as many potatoes without inter-

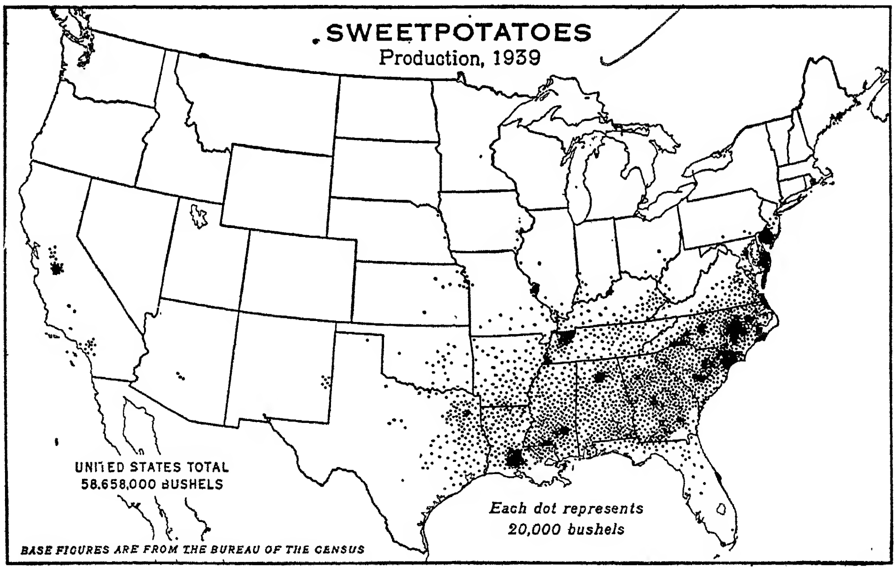
[7] United States Foreign Trade in Potatoes (millions of bushels):

	Production	*Potato exports*	*Potato imports*
1929	322	2.4	6.0
1938	355	2.7	1.0
1939	318	2.5	1.9
1940	375	2.5	0.9
1941	355	2.6	0.6
1942	370	1.3	1.1
1943	465	...	...

fering with other crops. If we could sell a surplus of 40 million or 400 million bushels of potatoes in the form of flour, cow feed, starch, and alcohol, as in the case of Germany, it would be a boon to agriculture and might help to stabilize the production of this perishable and valuable foodstuff.

4. Sweet Potatoes, Cassava, and the Sago Palm

Sweet Potato Production in the United States. The torrid zone is often said to have great possibilities for the support of human life. One evidence of this is the great abundance of starch-producing plants. One of these is the sweet potato, which causes the tropic denizen to have small regret over the fact that the white potato will not grow there. The sweet potato supplies the same need in human diet, and differs from the white potato only in the greater amount of sugar and nourishment that it contains (see Table 22). The sweet potato is a perennial where there is no frost, yet it will grow a crop in the warm summer as far north as Iowa or New York, and is a crop of considerable importance in American agriculture. Fortunately the sweet potato requires even lighter and sandier soil than the white potato and is, therefore, much grown on the sandy lands of the costal plain in New Jersey, Maryland, and Virginia, where it is largely produced for shipment to the northern states. Similar sandy spots in Iowa, Illinois and the North Central States render similar service for the interior of the United States and western Canada. This crop is also very widely grown throughout the South as a local food supply, where the



The sweet potato, which thrives on the coastal plain and other sandy soils of low natural fertility, shows that the Atlantic Coast Plain and the Gulf Coast Plain and Florida have a great potential carbohydrate food reserve if called upon to use it.

people have the alternative of rice or sweet potatoes as their chief starch food in addition to corn bread.

Like the white potato, the sweet potato has enormous possibilities of increased production, if demand should arise. Unfortunately, it is even more difficult to market than its white cousin. A temperature of forty-five degrees gives it a chill which causes it to spoil in a short time. Therefore, it must be kept in warm cellars, although a pit of sand beneath the kitchen floor in many a southern home has kept them for many months. Should sweet potato flour meet with large demand, the production of this crop might easily rival wheat in quantity of human food without serious interference with any of the world's existing agriculture. It is not difficult to obtain three to four hundred bushels per acre on southern sand of low fertility. Some years ago the first sweet potato starch factory in the United States was established at Laurel, Miss., to use jumbo-size potatoes that are too large for table use. This is a promising industry. Starch has many uses and the South has vast sweet potato lands.

Importance of the Sweet Potato in the Tropics. Although the United States has the largest recorded production, or 73 million bushels in 1943, the sweet potato is a universal food crop in the wet tropics, its original home, whether it be in the Spanish-speaking settlements of South America, the English-speaking Honduras, the West Indian Islands, the coasts of Africa or the Malay Peninsula. In Japan more than one-fourth of all manufactured starch is derived from sweet potatoes. Some varieties called yams grow large enough to weigh 40 or 50 pounds, but they have almost no commercial importance in the tropics because of their many rivals, the universal ease of their production, and the fact that there are few tropic cities large enough to require large movement of agricultural products. The low-valued sweet potato does not travel far.

Cassava. The garden in the rainy tropics always has some form of starch roots ready to dig. Cassava is one of these rivals [8] of the sweet potato that helps to fill the local need for a principal starch or bread-substitute food. To the peoples of the temperate zone it is a source of tapioca. To the tropic native it is both potato and bread. Like the sweet potato, cassava grows best in rich, sandy loam and needs abundant moisture. The plant reaches a height of 8 or 10 feet, and develops roots about 2 inches thick and sometimes as much as 6 feet long. It is a native of America, but it is distributed throughout the tropics and is extensively used for food in many districts, especially in equatorial South America, Guiana, the West Indies, West Africa, the East Indian Islands and the Malay Peninsula. In all these lands cassava cakes are a standard article of diet for the natives and replace to a considerable extent the corn bread of the American South, the boiled potatoes and rye bread of the European peasant, and all other breadstuffs of the temperate zone.

Experiments along the Gulf coast seem to indicate the possibility of extensive cassava growth in the United

[8] In Jamaica, one of the few tropic territories with statistics, cassava ranks third among the ground provisions which are the principal articles of food among the natives, yams coming first and potatoes second.

States.[9] In addition to its nutritious starch, the cassava root also contains the virulent poison known as prussic acid. Fortunately this poison is volatile and is dissipated by exposure to the sun or moderate heating, so that the cooked roots may be eaten with perfect safety.

Sago Palm. In the Far Eastern Tropics a form of starch is produced from the sago palm tree and extensively used as local food supply in Java, Borneo, Celebes, and adjacent islands. When a sago palm tree is about fifteen years old it blossoms profusely and produces a large amount of fruit. Before blossoming all the material for the production of this fruit is stored in the trunk of the tree in the form of starch. To get this accumulation of years the Malays, just before the tree blossoms, chop it into pieces 2 or 3 feet long, soak out the starch, dry it, make it into flour for cakes, or the "pearled" rounded masses which are to be bought in grocery stores as sago.

5. *The Banana*

The banana is a great starch food, a rival of the potato, the sweet potato, rice and cassava. It has been cultivated so long it has ceased to produce seed. Wherever the climate is always warm and the rainfall suffices to support a dense tropic forest, the banana is at home. The banana belt goes around the world and reaches slightly into the north temperate zone, as at Madeira. With its great bunches of fruit it stands almost without a peer among nature's gifts to man. Wheat, corn, rice, and the potato we get by arduous labor and tillage, but one only needs to stick a root of a banana tree in the tropical earth and give to nearby rival plants a few blows with the machete (a sword-like knife common in the tropics) to keep the young banana plant from being overgrown. By the time the first stalk has produced its great gift of fruit, other young shoots from the original plant are coming up to replace the old one and bear fruit in their turn, a continuous and prodigal process. The amount of food per acre is greater than from any grain but far less than is often reported. Two hundred bunches per acre is considered a good crop in most banana lands, and the drain upon the soil is less than that made by a small crop of wheat. The common absence of plowing reduces to a minimum the soil waste from erosion which has so nearly destroyed the ancient world and is destroying the United States at a rate that is terrifying to all who contemplate the future.

This ease of banana production should be emphasized in its effect on tropical life. More than any other one plant, it helps to make life easy in the tropics. In the Congo Basin and other humid parts of central Africa, where the climate is so bad for the white man, the nutritious banana is said to be the main article of diet for many, probably scores of millions, of the Negro race. It merely replaces the potato of the north European peasant, and the rice of the

[9] The dasheen, a variety of the Polynesian taro, has a starch-yielding root and is cultivated in the tropics to the extent of 100 species. It was introduced into the United States from Puerto Rico in 1905, but only since 1913 has its use as a vegetable been slowly increasing in competition with our other starches. As it requires a rich, loamy soil, an abundance of moisture, and a frost-free season of at least seven months, its commercial production is limited to the coastal plain lands from South Carolina to eastern Texas.

southern Chinese. Scores of varieties are grown throughout the East Indies, south China, much of India, many of the West Indian Islands, Central America, the Philippines, and other tropic lands from Mexico and Hongkong to Paraguay and Queensland.

Banana in Commerce. Owing to the perishable nature of the fruit and consequent necessity of quick transportation, it was unknown to most people in the temperate zone prior to 1870. Following the first successful shipments its advance in popular favor was rapid, consumption in the United States doubling every five years from 1870 to 1900. The banana competes with our home-grown fruits and, to a limited extent, with the cereals and the potato, of which it is almost a duplicate in nutritive content (see Table 22).

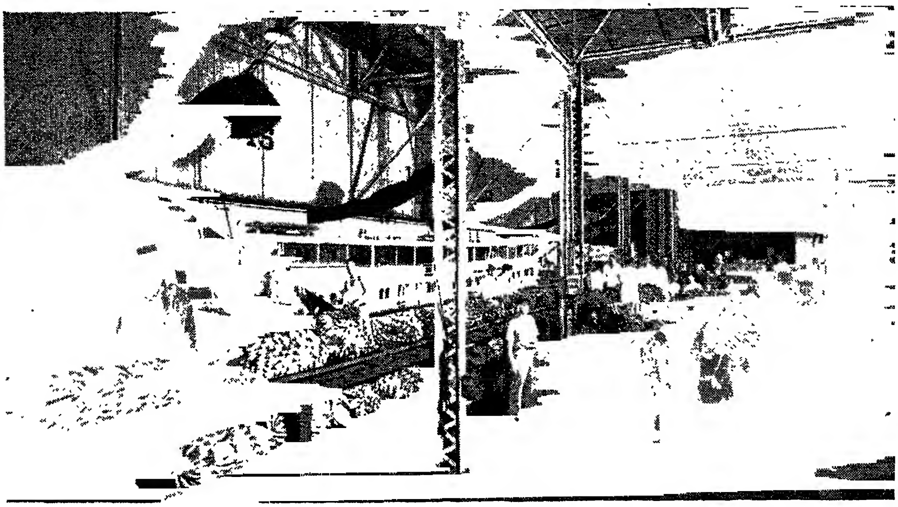
Because of the difficulty of transportation, only certain favored locations in the tropics are near enough to the markets to export the banana. Central American and Jamaican bananas reach New Orleans or Galveston in from three to five days; the trip to New York or Philadelphia takes six or seven days. The supply in Europe is inferior to that in the United States, because that part of the tropics lying nearest Europe is the Desert of Sahara where the banana cannot grow. The European supply has for a long time come from Madeira, the Cape Verde, and the Canary Islands off the west coast of Africa; but fast steamers now carry the product of the West Indies and Central America to Great Britain.

Importance in Caribbean Countries. The nearness of the United States to the steaming hot plains that border the Caribbean Sea and the Gulf of Mexico has given us a favorable place from which to draw our supply of bananas. Owing to the unwholesome climate along the Central American coasts, nearly all the people live on the more healthful interior plateaus and the best banana lands have long lain idle. The comparatively new banana commerce, however, has caused recent rapid increase of settlements, mostly West Indian Negroes, along the low eastern coasts.

The indolent native raises a few bananas for his own food; he does not ordinarily grow fruit for the international trade. Banana cultivation on a commercial scale requires capital such as only big industry can provide. The large plantations, with their railways, villages, stores, schools, hospitals, radio stations, docks and ships, are owned by private corporations and the land is worked by thousands of native laborers under the supervision of northerners. The United Fruit Company owns hundreds of thousands of acres of land scattered in half a dozen countries, and annually ships millions of bunches to the United States and Europe in specially constructed steamers.[10]

When the shiploads of bananas reach our ports, they are unloaded by elevators, carried to the doors of the refrigerator cars in mechanical conveyors, and hurried on express trains to the interior. From New Orleans, latitude 30°,

[10] The United Fruit Co. is a classic example of vertical integration of industry, controlling every step in production from the time that the fields are cleared and planted until the bananas are delivered to the wholesalers in the urban markets of the United States.—See J. Russell Smith and M. Ogden Phillips, *North America*, Harcourt, Brace & Co., New York, 1942, pp. 899-903.



Bunches of bananas traveling on a belt conveyor from shipside down the pier for shipment inland. The thing at the left of the second man from the left appears to be steps. It really is step-like pockets in a belt conveyor, with a bunch of bananas lying in each pocket, as the thing comes up out of the hold of the ship and then down. The ship is immediately alongside of the pier. Windows in staterooms are visible just back of man Number 3 at the left.

whole trainloads are sent northward and northwestward into the lands of cotton, corn, and wheat, latitude 40°-50°. As a result of this highly organized international trade a hungry man on the streets of an American city finds in the ripe bananas the cheapest portion of nutritious, palatable and easily digestible food within reach.

This comparatively new trade has been little short of revolutionary in the effects it has had in the economic development of the Caribbean countries. While nearly all of them have at least a small banana trade, the seven leading sources from which we obtain our fruit are Honduras with 13.3 million bunches shipped to the United States in 1940-41, Panama 6.7 million bunches, Guatemala 6.6 million, Cuba 4.8 million, Costa Rica 4.7 million, Mexico 4.5 million, and Haiti 3.7 million. In practically all of them bananas are the leading cash crop. There is plenty of room on the Caribbean for more plantations should the demand arise.

Banana flour is now an article of commerce. This seems to offer room for expansion of banana growing, as the ease of transporting the dried product will permit remote localities to send them to market without the use of expensive refrigerator ships. *But we change our food habits slowly.*

Difficulties of Banana Growing in the Hurricane Belt. The people who live upon the shores of the Caribbean and the Gulf of Mexico have a double dependence upon the banana. It is to them a great supply crop because it is a standard article of food,[11] and to many of them it is also a very important

[11] Vendors peddle push-cart loads of fried plantains (cooking bananas) among the dock laborers in Caribbean harbors.

money crop. Jamaica shows its importance as a money crop. Fruit exports of that island, chiefly bananas, have risen from $15,000 in 1869 to $350,000 in 1879, $1,500,000 in 1889, $4,000,000 in 1899, $7,500,000 in 1909, $14,500,000 in 1938, but only $1,400,000 during the war year of 1942.

The banana is a vulnerable crop with special hazards of its own. A hurricane sometimes beats the banana plantations of an entire district to shreds, and a severe hurricane is indeed a national calamity. High winds in May and June, 1923, did $1,250,000 worth of damage on the east coast of Honduras. As a form of hurricane insurance, the United Fruit Co. has its plantations widely distributed in Cuba, Jamaica, Guatemala, Honduras, Nicaragua, Panama, and Colombia so that no single hurricane can get them all. The company knows that it would be bad business to put all of its bananas in one country.

Perhaps an even greater hazard to banana production is sigatoka, the dreaded leaf disease, which appeared in Trinidad in 1933 and spread throughout the banana districts of the Caribbean area causing tremendous crop damage.[12] In time the fruit companies found a remedy by spraying the plants with various preparations containing copper. Many hundreds of miles of pipes were laid down for spraying the plantations, and it is said that this cost as much per acre as the initial expense of clearing the land and bringing it into production. One result of the appearance of sigatoka on the humid east coast of Central America has been the opening of new plantations on the drier Pacific coast where the banana plant is less susceptible to infection. In 1939 plantations along the Pacific coast accounted for more than one-half of the output of Guatemala and nearly one-third of that of Costa Rica.

6. *The Apple*

Distribution of the Apple Tree in America. The apple tree is the longest lived, if the palm and the olive are not considered, and excepting the cherry, it is the largest of all our fruit trees. Its trunk frequently attains a diameter of 3 feet, a girth of over 12 feet being known in Pennsylvania. A large tree will often produce ten to twenty barrels of fruit. From New England to North Carolina it is not uncommon to find trees healthy and bearing at the age of 100 years. The tree is hardy and adapted to a wider range of soil conditions than any other important fruit. It grows wild along the fence rows and in fields from Nova Scotia to North Carolina and throughout most of the Ohio Valley. In the long and humid summer of the Cotton Belt it is not at its best, and is grown only to a limited extent for local use. It does well, when the buds are not destroyed by frost, on the plains and prairies of the Corn Belt, reaches a high degree of perfection in the Ozark Plateau, while the handsomest and highest-priced apples in America are produced in the Rocky Mountains and the Pacific Northwest.

In the northern part of the North Central States the severity of the cold waves of winter combined with the heat

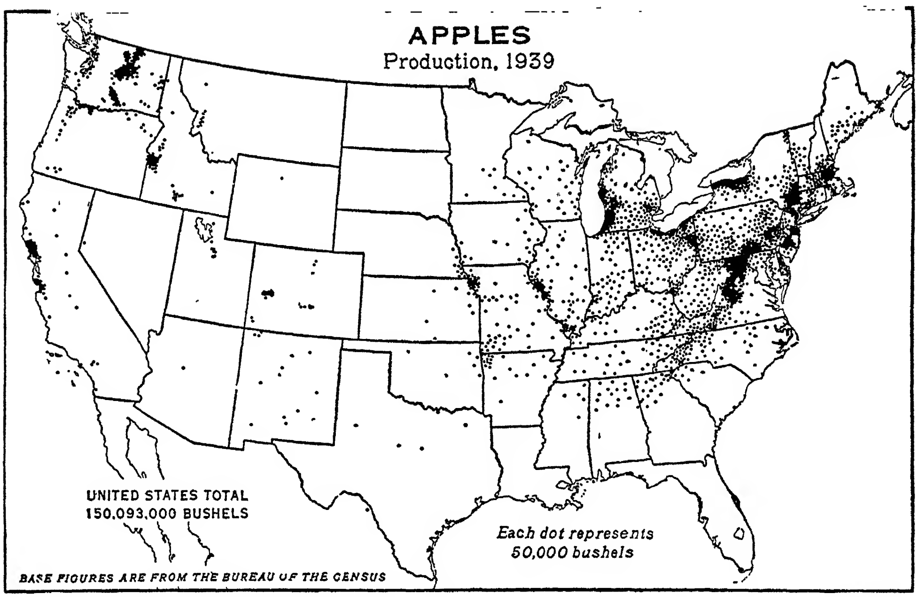
[12] See Earl B. Shaw, "Banana Migration and Sigatoka," *Jl. of Geog.*, vol. 40, December, 1941, pp. 350-354.

of summer has somehow served to make the trees short lived, and there are few varieties that can survive even for short periods the rigor of that climate, and most of those varieties are of Russian origin. In the early settlement of Dakota one man planted some thousands of apple trees and seeds each year, getting varieties from all parts of the world, and as a result of many years' experiment he found just one apple tree that could resist the winter climate. That survivor has become the parent of most of the apple trees in that part of the country. Continued hybridization and testing now in progress will probably produce apple trees for the Canadian wheat farmer.

There are over 1,400 named varieties of apples in the United States, most of them of local value only. Some growers manage to have fresh fruit on hand from their own cellars throughout the entire year, and while this is uncommon, apples are now in the market of most cities every day in the whole twelve months.

The Apple as a Supply Crop and as a Money Crop. In regions where the tree will thrive, a few apple trees for the family supply were until recently a part of the equipment of almost every American farm. The growth of perfect apples is difficult, much more difficult than it was before world trade and the introduction of new plants brought their evil accompaniments of foreign insects, rusts and blights. Transportation of the fruit to market without bruising is also difficult; the packages are expensive and the fruit has large bulk in proportion to its value, hence the development of apple growing as an industry to supply distant markets is comparatively new. Since we have such a wide territory suitable for apple culture, the origin of apple-shipping districts has been a matter dependent upon some minor advantage of location or upon some pioneer grower showing the people of his locality that this crop could be profitably marketed. Commercial apple growing in America is an important industry in localities as widely separated as Nova Scotia, Ontario, Delaware, northern Georgia, Missouri, Michigan, New Mexico, Arkansas, central California, and the Pacific Northwest. Over a period of years, however, three states generally produce more than one-third of the American commercial apple crop, namely, Washington, New York, and Virginia.

Irrigated Apples of the West. In the more newly settled states of the Rocky Mountains and north Pacific coast there are many irrigated districts that produce large and beautiful apples. Some of these, as the Hood River Valley in Oregon, and the Yakima, Okanogan, and Wenatchee valleys in Washington, have become well known in the eastern part of the United States through the beautiful fruit they send out. For some years the state of Washington, aided by irrigation and care, has led all others in commercial apple production, with an average annual output of 28,000,000 bushels during 1934-41. Parts of Idaho, Montana, Colorado, and a few sections of northern California are equally well fitted for the growth of this fruit. Because of the bright sunshine of the semi-arid climate, western apples are the most highly colored in America. These western fruit districts, which must be in the valleys, are of restricted area, because of the limitation imposed by soil



The map of apple production shows clearly the lake shores, Appalachian and other eastern hills, and western irrigated valleys.

requirements, irrigation, water drainage, air drainage, and protection from strong winds. California apples are grown chiefly in the Coast Range and coastal valleys in the central part of the state.

During the past decade production in the Pacific Northwest has increased more rapidly than that of any other section of the United States, but profits have not always been satisfactory. Owing to the small population of the Rocky Mountain and Pacific region, the apple growers of the Northwest must depend for their market very largely upon the eastern states and Europe, which subjects them to a heavier transportation cost than must be borne by their competitors in the East.

Apple Growing in New York and Virginia. New York ranks second to Washington as a commercial producer of apples, with an average output of 15,800,000 bushels during 1934-41. Four counties on the shore of Lake Ontario in western New York have for a number of years been the most important shipping district in the United States. The Erie Canal and the railroads that followed it gave this region an early advantage of transportation to both eastern and western markets, and also made low prices for grain and animal products that had been staples there. In addition to this disadvantage for growing staples, and the advantage for apple transport, there is also an advantage in production. The large bodies of water with their melting ice in spring serve to delay the blossoming time until there is small danger of injury from frost. Likewise in autumn the warm waters of the lakes delay the killing frosts. These advantages for apple growing

Plowman's Folly. The ground here is not very sloping, but the owner was brought up in the era of mythology, when the apple medicine man said the apple orchard should have clean cultivation. Sheet erosion with every shower has removed a foot or more of topsoil. The best apple orchards are now conducted with controlled vegetation to hold the soil. See Experiment Station at State College, Pennsylvania, and the orchards of Senator Harry Byrd, of Virginia, the largest apple grower in the world.

were not fully appreciated until after the Civil War, when grain growing had become unprofitable, owing to the competition from the new, rich, cheap lands of the West. The farmers in New York had to find some other crops than grain in order to realize satisfactory profits, and in this district of the lake shore plain the alternative was apples, as in other districts it became dairying. But even here, although apples are the chief money crop, there is no county in which the orchards cover more than a tenth of the land surface, a rather surprising fact, tending to show the rarity of the entire dependence of any locality upon only one crop. The prediction has been made that within fifty years the south shore of Lake Ontario will become one continuous fruit orchard, a prophecy which appears reasonable.

The lower peninsula of Michigan is important in the production of apples for reasons very similar to those prevailing in western New York. The great development of apple orchards close to the eastern shore of Lake Michigan and their striking absence on the west side, serves to emphasize the combined influence of the lake and the prevailing westerly winds. The Michigan crop, however, is generally surpassed by that of Pennsylvania, our fourth largest apple-producing state.

For some years Virginia has ranked third in commercial apple production, its annual crop averaging about 11,000,000 bushels. It is probable that Virginia has two apple districts with quite as large a proportion of the land planted in apples as is to be found anywhere east of the Rocky Mountains. First, in the Great Valley of Virginia and West Virginia not far from the cities of Winchester and Martinsburg is a low ridge called Apple Pie Ridge, where about the time of the Civil War an enthusiast planted an apple orchard of 20 acres which promptly brought him ridicule of his neighbors and eventually brought

him many thousands of dollars. This started his neighbors to planting apple trees, and today there are several million productive trees in the locality, a gorgeous sight at the time of the annual Apple Blossom Festival.

Along the eastern slope of the Blue Ridge Mountains in central Virginia is another apple district from which large quantities of finely flavored varieties are annually exported to England. It is claimed that where the Chesapeake and Ohio Railroad crosses the Blue Ridge west of Charlottesville, one can walk along the slope of the mountain for 7 miles and pass continuously from one apple orchard into the next. Neither of these Virginia apple districts has any known advantage either in production or transportation over other territory in the United States except for the accident of an early start, which means that the industry is well established with a full equipment of satellite industries, trained labor and business organizations. The same thing may be said of nearly all American special crop localities despite much local belief to the effect that *this* place is unique.

The Open Mississippi Valley and the Ozark Plateau. On the southern edge of the Corn Belt in Illinois, northern Missouri, Iowa, and Kansas have been planted some very extensive apple orchards. Because the sweeping cold waves that come unimpeded down the open Mississippi Valley have frequently frozen the fruit buds in April and May, many a fruit grower has given up hope, pulled up his trees, and turned to crops better suited to the climate. In the Ozark Mountain region of Missouri and Arkansas, however, an extensive apple culture has developed. About 1880 a pioneer in commercial apple growing planted an apple orchard of 1,400 acres. He took magnificent specimens of the fruit to the World's Exposition at Chicago in 1893 and advertised to the world the virtues of the Ozark Mountains as a place for apple growing. Seven years later, the Census of 1900 showed that Missouri led all the states in the Union in the number of her apple trees. Orchards of from 100 to 1,000 acres in size were common. The rapid extension of the industry was made possible by the very low price of the land in the Ozark plateau and ridges, an old, worn-down mountain system ill suited to grain farming, but very well suited to the production of fruit. The elevation and the protection of mountain location causes it to escape many of the freezes that are so destructive to the open plains to the north and east, but Missouri has not kept up with previously mentioned apple areas.

Production Hazards. An apple tree, like most other trees, will rarely bear two heavy crops in succession, and this fact, in combination with occasional injuries by frosts, hail, fungus and drought, makes it exceedingly rare that all the different export apple districts have a full crop at the same time. When they do, as in the year 1896, the crop exceeds the demand, and they have almost no value (seventy-five cents per barrel in March, 1897). In 1926 and 1937 millions of bushels were not picked.

As a result of our world commerce and the introduction of new varieties of plants, each locality also gets nearly all of the world's weeds and plant enemies. Thus came many insects, fungi, rusts, and other plant enemies which combine to destroy nearly all the fruit that forms

Apples, peaches, pears, plums and cherries are like the potato vine—attacked by fungi and insects and successfully protected only by a number of sprayings. This is a picture of a demonstration meeting in Connecticut, not a commercial spraying.

on the trees of the unprotected orchard. Fortunately they can usually be held in check by skillful care, much of which consists in spraying poisonous liquids on the trees. This makes the production of good fruit one of the most scientific of all pursuits, and is transferring it from the small orchard of the general farmer to the large orchard of the specialist in the better located fruit districts. This is causing rapid increase in the commerce in the apple which is more generally used by all classes in the United States than in any other country.

The Effect of Refrigeration. Under good storage conditions some varieties of apples will keep well for a full year, so that cold-storage warehouses, refrigerator cars, and refrigerator ships have made possible the easy distribution of American apples all over this country, and their export to Europe, and have also made possible their sale and use every day in the year. The United States normally exports about 15,000,000 bushels each year, chiefly to the United Kingdom. Minor shipments are made to Cuba, Brazil, Mexico, and other tropical American countries, where the apple cannot be grown.

The greater distribution of fresh apples has caused a marked falling off in the use of dried apples.

Canadian Apple Growing. Canada is an apple exporter second only in importance to the United States, Canadian exports averaging about 7,000,000 bushels a year. The apple does well from Lake Huron to the mouth of the St. Lawrence and two localities have utilized their especial advantages for developing the apple as a money crop for the foreign trade. The most famous apple district in Canada is the narrow Annapolis-Cornwallis Valley in the western part of Nova Scotia which is warmed by the Bay of Fundy and protected from winds by a sheltering mountain range, and is well suited to the apple. These advantages, together with an early start and convenient access to a harbor, have given it a development of

apple growing which has made its product famous in Britain. The export apple is the chief money crop and financial dependence of its people. The other eastern Canada apple district is near Niagara Falls on the peninsula between Lakes Erie and Ontario, where it has the protecting influence of the water similar to that which benefits the New York lake shore apple belt, of which it is really an extension separated only by the Niagara River.

Canada west of the Rockies also has an important apple region—the Fraser Valley of British Columbia, where the fruit is grown under irrigation as in Oregon and Washington. British Columbia apples like those of our own Pacific Northwest are exported to Europe by way of the Panama Canal.

European Apple Growing. Apples are at home in Eurasia from Edinburgh to the Mediterranean, from the Bay of Biscay to Tokyo. They are quite commonly grown throughout western Europe, being the chief fruit crop in the 250,000 acres of British orchards. But western Europe does not supply enough for its own use. The regions of greatest production on the continent are the mountain valleys in the highlands of south Germany, of Switzerland, and of the eastern Alpine regions in Austria. The individual orchards of Europe are smaller than those of the United States because of the small size of the farms in all the above-mentioned apple-growing regions. The total European production is large and there is a heavy traffic to the cities of Berlin, Paris, and London, and the numerous small towns of the manufacturing districts of the Rhine Valley and the adjacent territories of France, Germany, Holland, Belgium, Switzerland, and Austria. In some cases canal boats are loaded with apples in bulk, taken to the city, and tied up to the bank until the load is sold out to consumers who visit the boat.

The Apple in Asia. From Istanbul (Constantinople) eastward the apple can be grown in almost any location where there is sufficient water, but this must usually be supplied by irrigation, although it grows wild in many mountain districts. The fruit is quite commonly grown by the Chinese farmers of the upper Yangtze Valley and in all cooler parts of China and to some extent also in Manchuria, Korea, and Japan. Although important in meeting the wants of the local population, it has not in this region of undeveloped transportation become an important article of commerce.

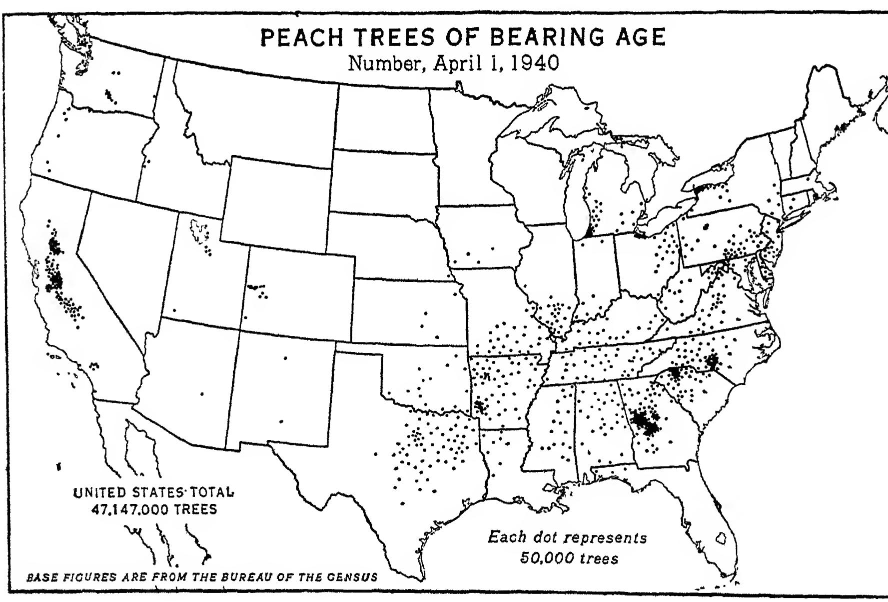
The Apple in the South Temperate Zone. The south temperate zone, with the reverse arrangement of its seasons, can send its fresh autumn fruits to the North at the end of winter when ours are gone or have been longest in storage. The south temperate zone has climate and resources that seem well suited to the apple, particularly central Chile, New Zealand, and the Island of Tasmania, which is about as large as West Virginia. It much resembles this state in its mixture of mountain and valley, its good rainfall, and its suitability to the apple, and in its mountain orchards. South New Zealand with a similar climate is another important producer. Australia has had a marked increase of apple growing, particularly in Victoria, where they are the main fruit crop. In addition to supplying the local demand these countries have a growing export, principally to Great Britain. The total

export from the southern hemisphere, however, is small in comparison to that of the United States and Canada.

7. The Peach

The Perishable Nature of the Peach and Its Commercial Effect. This delicious fruit is regarded as more of a luxury than the apple, chiefly because by its perishable nature it is less adapted to being a staple of commerce. The standard market peaches cannot be kept in good condition more than ten days or two weeks without excessive cost, while some varieties of apples will keep in good cellars from October until June. But such is the high esteem of this fruit that since the coming of fast trains, refrigerator cars and steamships, it is marketed all over the United States and Europe and even sent across the ocean. Owing to the perishable nature of the peach there is but one day upon which it can be picked for market. The day before it is too green, a day later it is too soft. The rapid increase of frozen foods promises to increase the demand for peaches. They can get *ripe* before they are picked, if they are to be frozen.

The Susceptibility of the Tree to Climatic Influence. The peach tree is apparently a native of Persia, and grows well in special locations from the Atlantic coasts of Portugal and Africa to the Pacific coasts of Japan, but like the apple, the peach is nowhere throughout this vast region an important article of commerce except in small sections of Europe. The tree, unlike the apple, yields well only in restricted localities under special climatic conditions. It has two chief climatic perils—early bloom and spring frost injury to blossoms and winter killing of buds and trees by very cold weather. In Germany, Holland,



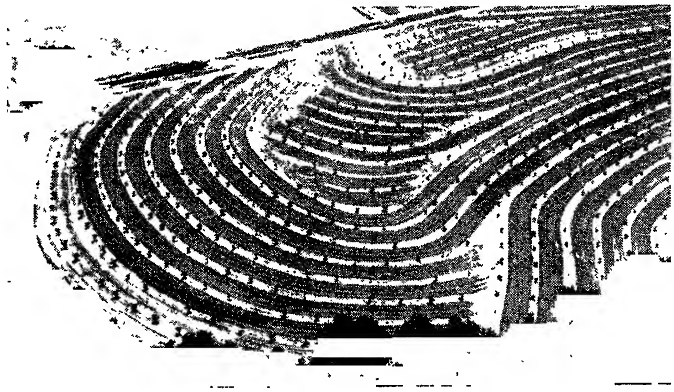
The text tells the why of each of these concentrations of peach trees.

Belgium, the north of France, or Great Britain, the tree can only be grown under the artificial conditions of hothouses or on the south side of walls where it is trimmed so that it spreads out like a fan against the flat surface, thus catching the direct rays from the sun and the heat reflected from the wall. The European settlers brought these varieties to the United States. The peach tree in north Europe needed heat and by the strange adaption to the environment which plants possess, it gradually acquired a reddish bark, a color which absorbs more heat from the rays of the sun than a light color, which reflects more of the sun's rays, just as light clothing reflects heat and is cooler than dark colors which absorb heat. But by acquiring ability in England to absorb heat, the peach was fitting itself for destruction in America, where over the whole eastern half of the country with its continental climate, the peach has a tendency to bloom in the first warm days of spring and then have the blossom or young fruit killed by a subsequent frost. This has set the plant breeders to searching for hardier varieties,[13] but at best the peach can only become an important money crop in regions somewhat immune from early frost. The United States has at least several such districts.

The Peach Belts of the Great Lakes. Peaches are grown along the shores of the Great Lakes for the same reasons that caused the apple to be important. Orchards on the shore of Lake Michigan can ship by boat to Chicago. Peach growing is important in the Appalachian and in the Potomac drainage areas. The advantage of the hill over the plain is due to two climatic factors. First, the coolness of elevation makes a later start in spring growth. The second advantage is air drainage. Cold air is heavier than warm air, and upon frosty nights it settles to the lowland where fruit buds freeze, while the hills are frost free. Due to this advantage a peach belt developed rapidly upon the mountain slopes of the Blue Ridge and the Alleghenies in the Potomac drainage basin in southern Pennsylvania, western Maryland, and the eastern part of West Virginia. Here some of the most highly organized of all agricultural industries were located because trunk line railroads gave direct train service to Chicago, Boston, and points between, but the truck is getting an increasing share of the transport. The peach crop is highly seasonal. The Potomac Valley does not compete with the shore of Lake Ontario, and Georgia does not compete with Maryland. Upland orchards at the southern end of this Appalachian Highlands cause Georgia, South Carolina, and North Carolina to send hundreds of cars of peaches per day to northern markets for a time in July. During 1934-41 the Georgia peach crop averaged 4,900,000 bushels a year, or about 10% of the nation's output.

California Peach Growing. California regularly grows more than 40% of the American crop. In the eight-year period,

[13] The hardiest varieties of peach, like those of many other fruits, have come from Japan and China rather than west Europe. This is but natural because west Europe has the oceanic climate, mild in winter, cool in summer, like our own Pacific coast, where west Europe varieties thrive, while Japan and China have continental climate, cold in winter and hot and humid in summer. While west European plants often perish of blights in the southeastern part of the United States the Far-Eastern plants usually thrive with a veritable riot of prosperity.



Hundreds of thousands of peach trees in the Cotton Belt are receiving the proper cultivation with little or no loss of soil through erosion. This view of such an orchard in South Carolina shows how rows on the horizontal adjust themselves to the slope and therefore cultivation furrows do not wash. It is easy here to pick out steep slopes and gentle slopes and to observe near the top a long, curved, main terrace that will carry away any excess of water slowly and therefore harmlessly. When one thinks of the past ruin through erosion, the long distant future, this is an exceedingly important illustration.

1934-41, California had an average annual production of 22,700,000 bushels. Bordering upon the Pacific Ocean with the prevalent warm westerly winds from that great body of water, California has a normal oceanic climate free from the cold waves and strong winds that spread over all territory east of the Rocky Mountains. Peaches can, therefore, be raised with more reasonable assurance of getting a crop, but frost destruction is also known there, and the glutted market has likewise wielded its traffic-stopping hand.

Peach orchards are of great extent, and, owing to the perfection of the California methods of picking, packing and shipping, the fruit is at times sent to all the larger eastern cities and at times even as far as London. The bulk of the crop, however, is grown for the purpose of drying or canning, the large-sized, firm-fleshed California canned peach being a favorite on the market.

European Peach Growing. In England the peach is always a high-priced luxury, the small import into that country coming chiefly from the south of France, and from Italy. There appears to be no good reason why proper development of transportation facilities should not give western Europe a cheap and abundant peach supply from Spain, Portugal, and North Africa. The increasing export from the United States and Canada shows that the fruit can stand the transportation.

The Peach in the South Temperate Zone. The peach does as well in the south temperate zone as it does in the north temperate zone. It is said that peach tree wood was for many years one of the chief sources of wood supply for the city of Buenos Aires in Argentina, and peaches of excellent quality are grown in Chile, Australia, New Zealand, and South Africa, but chiefly for home consumption. Because of the

difference in seasons small shipments of excellent fruit are carried by fast steamers to Europe in February and March. They are also sent to the United States, but many of them decay in the two or three weeks that they are in transit, with the result that they retail at exorbitant prices, often twenty-five cents each, and the luxury market is naturally very limited.

8. The Canning of Fruits and Vegetables

The Canning Process and Its Service to Mankind. The process of canning food, which was discovered in 1786, is one of the great boons to humanity. It consists in hermetically sealing the food product, and then cooking it, often above the boiling point, to destroy all bacteria. Under these conditions the food keeps almost indefinitely.

The first experimenters found that food could be preserved in bottles by means of heat. A half century later another pioneer was declared mad because he proposed to preserve foods in tin instead of in glass. It took the American Civil War to make us use this wonderful process and people still living can remember when "tinned foods" were regarded with almost superstitious prejudice.[14] By 1883 canning methods had been so improved that machinery did nearly all the work, including the soldering of the cans and even the pasting and trimming of the labels. The industry is now thoroughly established as a source of food supply for the masses. Between 1909 and 1941 the per capita consumption of canned vegetables in the United States increased from 14.5 to 38.6 pounds, while that of canned fruit increased from 3.0 to 19.3 pounds.

Before the coming of railroads, steamboats and canning, a crop of tomatoes could be consumed only within a few miles of the place in which it grew and within a few days from picking time. After transportation by rail and boat was organized and improved, the tomatoes might be carried several hundred miles, but they still had to be consumed within a few days. After the canning process was perfected and developed into an industry, the perishable products of field or orchard could be preserved for consumption at any time within several years and in any corner of the world to which they could be cheaply carried. This elimination of the time limit on perishable commodities has revolutionized food habits. It has also revolutionized agriculture in many localities by suddenly giving perishable products access to the world market. The distribution of crops and of production now depend, not upon a nearby market, but upon environmental and economic conditions which make certain localities best able to produce certain products.

The importance in consumption is even more marked. Most parts of the world can now have many kinds of cheap foods previously unused or even unknown. The workers in a paper mill in the woods of Maine may now eat the tomatoes and peaches of Maryland, the cherries and apricots of California. The same is true of the gold digger upon

[14] The industry was so little esteemed that until 1872 it had not produced a can opener, which today is the *sine qua non* of housekeeping.

the Klondike, of the engineer on the Panama Canal, of the rubber gatherer in the jungles of the upper Amazon, and the whaler who spends a season in the Antarctic Ocean. A century ago, the whaler on a voyage of a year or two often came home, if he came at all, sick with scurvy, a disease due to undernutrition from poor food of insufficient variety. But when Nansen and his men drifted in the Arctic ice for years in an attempt to reach the North Pole, they returned in perfect health because they were nourished with all kinds of canned and preserved meats, vegetables, fruits, fruit juices, and extracts. Admiral Byrd's parties repeated this experience in Antarctica.

Canning, more than any other invention since the introduction of steam, has made possible the building up of towns and communities beyond the bounds of varied production.

The Extent of the Industry. Practically all classes of food, fruits, vegetables, soups, fish, meat, and even nuts, bread and pudding are now preserved by canning. The canning factories of the United States prepare yearly from 50 to 60 pounds of fruits and vegetables for each man, woman, and child in the country. Among the vegetables, beans are by far the most important, followed by tomatoes, peas, and corn, while among the fruits the peach leads, followed by pears, fruit salads, cherries, and grapefruit. The output amounts to hundreds of millions of dollars per year, and is produced in nearly all parts of the United States. Canning tends to be scattered in small towns wherever a surplus of some product is available, such as may occur in a truck farm or orchard district. Furthermore it is capable of being operated on a comparatively small scale, even by a farm family. Owing to the seasonable nature of the work, the labor is nearly all done in the summertime and often by transients who flock in from nearby cities for temporary residence of a few weeks or months. Although widely scattered, the canning industry in the United States has three distinct belts showing greater development than other regions.

The Atlantic Plain. The first of these regions to develop the industry was the Atlantic Plain. Maryland is the center and most important part of the Atlantic Plain canning district, which extends from North Carolina to New York. This section has become important for the same reason that made it important in the shipment of truck crops to the city markets, namely, the sandy soil which is exceptionally suited to vegetables, and not well adapted to the growth of other agricultural staples, especially wheat and grass. Maryland is the leading state, canning on an average one-third of our tomatoes and a large share of our corn. The exceptional transportation facilities, centering in Baltimore, have made it the only important big city center of canning in the United States. Ordinarily, canneries are located wherever a few farms grow a surplus of any crop. But the ease and safety of navigation on the many far-reaching arms of the Chesapeake gives Baltimore remarkable facilities for assembling farm products. They are brought by motor trucks and in steamboats from points as far away as Fredericksburg, Richmond, and Norfolk in Virginia, a great number of places on both sides of the Bay in Maryland, while the Chesapeake and Delaware Canal opens a way

for the Baltimore fruit boats to go up the navigable creeks of New Jersey to such towns as Salem and Bridgeton.

The sandy southern part of Delaware gives that state an importance in the canning industry that is quite disproportionate to its small area. Maryland and Delaware are important also because they are large peach and pear growing states due to the protecting influence of the waters of Chesapeake Bay.

The New York, New England, and Lake Region. New York, which is both a great agricultural state and a fruit grower, is the center of the northeastern belt, a region with great diversity of canned products. Although not the best possible place to grow it, New York and the New England states have long been important canners of corn. The New England summer is almost too cool and short to ripen the corn grain. For that reason Maine with a very small corn acreage cans a great deal of corn, since corn for canning does not ripen, but is harvested a full month earlier than it could be if used as ripened grain. Sugar corn is more valuable than common corn for the market, so that a small sugar corn crop on a New York or New England farm is worth as much as a larger crop of Illinois corn.

The center of corn canning has now moved west to the Corn Belt, however, with Illinois and Iowa as the leading producers. Wisconsin and Minnesota, farther north, have a large corn pack for the same reason Maine has.

The somewhat cool summer that makes of parts of New York, Michigan, and Wisconsin second-class corn producers, makes them first-class growers of peas, Wisconsin producing over one-half of the annual pack. If the same factory can lengthen its season by canning several kinds of fruits and vegetables, it is a great advantage through the better utilization of the plant. Thus a plant at Janesville, Wisconsin, begins its season in June with peas and ends it late in autumn with sauerkraut.

In northwestern Ohio is a good example of the specialization of agriculture through canning. Near the west end of Lake Erie, especially around Fremont in Sandusky County, it has been found that the black swamp land with its mixture of sand is well suited to cabbage growing, with the result that there now are several large sauerkraut factories within 10 miles and 3,000 acres of cabbage are annually grown.

Pacific Coast. The most important canning district is California. This state has become important from the combined influence of the climate, excellent for the growth of fruits and vegetables, and the great distance from eastern markets which makes it possible to ship in the fresh condition only an uncertain fraction, and that the most perfect, of the total crop. This state cans nearly all the apricots, the largest share of the peaches and other fruits, except apples and berries, and is very important in the output of canned tomatoes, peas, and asparagus.

The canning industry also has large possibilities in the other Pacific coast states. The Willamette-Puget Sound valleys of Oregon and Washington have a damper, cooler summer than California and for that reason are producing and canning large quantities of blackberries, raspberries, loganberries, and other small fruits.

The Possibility of Increased Production and of Overproduction. The possibilities of increase in the production of fruits, vegetables, and canned goods in the United States are very great. If, for example, the farmers of the United States could be assured 25 cents a peck for tomatoes at their farms for the next ten years, it is probable that their production would be increased tenfold, for they are now commonly grown for less than that price and occasionally the crops are so great that the factories cannot handle them and the tomatoes rot upon the ground by the hundreds of tons. The same thing is true of many other vegetables, including potatoes. This is a great deterrent to industry.

Even with the aid of the outlet afforded by canning, the small fruits and vegetables yield so enormously that overproduction,[15] with its glutted markets and frequent losses, is a factor which, like frost, is ever in the mind of the producer and almost annually visits each locality of varied production.

Foreign Trade in Canned Fruits and Vegetables. Canned fruits and vegetables are an important export from the United States to Great Britain and many other countries. England herself is an important manufacturer of preserved fruits—preserves being fruits so rich in sugar that they will keep without sealing. Certain brands of English jams and preserves made from the fruits grown in the south of England and even on the mainland of Europe are known throughout the world, are widely exported especially to British colonies and are extensively consumed in Britain, where bread and jam is a favorite article of diet.[16]

The possibilities of the production of canned fruits in the tropics are much greater even than that of canned vegetables in the United States, although little has as yet been done in this direction. Pineapples grown largely by Chinese and Japanese labor on the fertile lava slopes of the Hawaiian islands go mostly to canning factories. The export demand for Hawaiian canned pineapple has made the industry second in value to sugar. The product is widely distributed throughout the United States, where it competes with imports from Cuba and Puerto Rico. In the Strait Settlements, at and near Singapore, canned pineapples are produced by Chinese labor and exported largely to Europe.

9. *Dried Fruits*

The Shifting of the Industry to Lands with a Dry Summer. Before the coming of steam transportation, when each locality lived to a great extent upon the local resources and the farmer's family

[15] A most convincing illustration comes from Perthshire, Scotland, where the light soil is well adapted to the raising of raspberries and strawberries. About 1900 a growing demand for raspberry jam increased prices so rapidly that by 1903 growers were making profits of from $195 to $245 per acre. With the rush of new growers into this attractive field, lands renting as low as $5 to $8 in 1900 brought eight or ten times as much per acre in the next few years. Production of raspberries increased until the market was glutted and prices fell from $112 a ton in 1906 to $44 a ton in 1909. This was accompanied by a like rapid decrease in land values, one farm purchased at $487 an acre being offered for $49 three years later. This is an admirable description of the typical agricultural boom-over-production-glut cycle which has been repeated with variation of detail thousands of times. Sometimes the Spanish pig has to help finish up the crop of Spanish onions, and even China has overproduction of vegetables.

[16] Fruit jams, and especially marmalade, are found upon every British table, private and public, and are usually served with afternoon tea.

lived almost entirely upon the products of the home farm, the drying of fruits on shed roof, garden fence, and kitchen drier in humid America and Europe was almost as common as their production. The only other methods of preservation were the then expensive ones of preserving them in sugar or brandy or of pickling them in vinegar, which latter processes make of them merely a condiment. Steam transportation and world commerce have worked a quick revolution by developing a large traffic in dried fruits from those parts of the world having unusually favorable conditions for their production.

It is often easier to dry fruit in the sunny and rainless summer of countries having the Mediterranean type of climate and ship it great distances than to combat the difficulties of drying it at home with alternating cloud, shower and sunshine or artificial heat in evaporators. One exception to this is the drying of apples, an industry suffering from the competition of the commerce in fresh fruit. It is still extensively carried on in the eastern apple districts, especially New York, from which state thousands of barrels of dried apples are sent to Europe, chiefly to Holland, Germany, and Sweden, where they are used for food and for the making of wine.

Competition of California with South Europe. In almost any grocery store in the United States today, boxes of dried prunes, apricots, peaches, dates, raisins, figs, and currants may be seen, and the names and addresses stamped on the boxes will show that they have come into these American communities from many distant parts of the world. Most of them are from districts with a long dry summer, in which fruit exposed on trays beside the trees is dried by the constant sunshine with little labor except piling the trays and covering them on those rare occasions when rain threatens.

California names predominate in the list of addresses on dried-fruit boxes, although fifty years ago the labels usually showed European names. These industries grew up first in southern Europe but since coming to southern California have developed with surprising rapidity and now supply almost the entire home market and a large surplus for export. In contrast with the large and increasing use of canned fruits and vegetables, the per capita consumption of dried fruits in the United States was only 4½ pounds in 1941, as compared with 4 pounds in 1909. By far the greatest portion of our dried fruit production consists of raisins and prunes, which are followed in importance by figs, apples, peaches, dates, and apricots.

The Prune. One of the first of California dried-fruit exports to compete with Europe was the prune, a dried plum which has long been exported from several Mediterranean districts, chiefly France, where Tours is the best known center of prune production. Italy is second, and Germany produces some for home consumption. The recent large export to the United States has almost entirely ceased, and California prunes now compete with European fruit in the European market. In comparison with canned fruit, the dried fruit has the disadvantage of becoming wormy in summer, but it is much more concentrated and easily transported. Many dehydrators, using natural gas as fuel, have recently been installed in the Santa Clara Valley. These machines dry

prunes and apricots in 14 to 30 hours, whereas sun-drying requires 10 to 20 days, and the fruit loses less weight through fermentation and is much cleaner when ready for packing. Prunes in large quantities go from California in steamships through the Panama Canal or by rail to our eastern ports for shipping to Europe. In 1940 19,000 tons of American dried prunes were shipped to foreign markets.

The Raisin. The raisin has for centuries been an export of Almeria in eastern Spain, where the peasants for generations have kept vineyards and dried the grapes. Sultana raisins, produced from a seedless variety of grape, are grown along the eastern Mediterranean, the chief center being Smyrna (Ismir), with other centers of production upon islands in the Aegean Sea, and to a less extent in Greece itself.

This Old World industry has been transplanted to the Great Valley of California with such success that the city of Fresno is now known in many countries as a raisin center. Vineyards of raisin grapes cover the land for miles around, making Fresno county the second richest agricultural county in the United States. The preparation and marketing of this great crop is managed on a cooperative basis by the Raisin Growers' Association, which includes about 40% of the raisin growers of the state. Each member dries his own grapes in his own vineyard beside the vines, then hauls them to the great Fresno raisin plant where machinery does all the rest of the work until the seeded raisins are packed into a variety of boxes for shipment. Men worked for years to develop a seeding machine which takes the raisins and, by a process similar to that of the cotton gin, puts the raisins in one place and the seeds in another.

Before 1890 the United States imported an average of 19,000 tons of raisins a year, which decreased rapidly with the growth of raisin production in California. In 1940 our raisin imports amounted to only 55 tons, while we exported to other countries 49,000 tons of California raisins. California has available enough additional grape land to easily supply not only the home market but a greatly increased export demand.

The apricot is a close cousin of the peach which it resembles in many physical features, but because of early blooming, it is more sensitive to frost, and fruits regularly only in locations with good frost protection. In the United States it is grown in California, Washington, and Utah. The fruit is exported both fresh and dried. It is also grown in northern India, and the dried fruit transferred by caravans over the snowy and perilous Himalayas to Tibet and western China, where the product is greatly prized.

For thousands of years dried apricots and other fruits have been a local food supply for the peoples in the old oasis settlements of North Africa and western and central Asia such as Bokhara and Samarcand. These densely populated communities live upon irrigated lands, where streams fed by snows upon the central Asian mountains permit fruit and vegetable gardens to spread over a few square miles of the level plain. It was not until the Russian Government established rail connections with these isolated areas that the apricots became important as a commercial crop. With cheap transportation rates

these desert oases quickly developed a valuable dried fruit export and serve as a California to bleak Russia.

The Fig. Commercially the fig is a subtropical product. The tree is hardier than the orange, thrives over most of southern Europe and even survives in sheltered places in England, Texas, and many parts of the southern United States, but the production of the fruit was successfully managed in California only at the end of the nineteenth century. For many years the trees had grown well but bore no fruit because of the absence of a certain insect, a native of Mediterranean lands that crawls into the hollow cavity of the fig and fertilizes the many blossoms therein contained. The establishment of fig growing in California waited for the successful acclimatization of the insect, which was difficult and required many expensive attempts. Fig drying, during which sugar exudes from the fruit and clings upon it in white particles, is a laborious process which has until the present time had its chief center in Turkey, where in the valley around Smyrna figs are largely produced, making Smyrna the best fig market and Smyrna figs the best known in the world.

The Importance of the Date in Desert Countries. The date, more nutritious than beef (see Table 22), the fruit of a tall palm growing in many warm arid lands, is the bread of the desert, and also food for the beasts. Even milk cows in Oman, Arabia, are fed principally on dried fish and date kernels. The date is called the tree of the desert, but it really requires much water, and is a tree of the oasis. Underground streams of water occasionally reach the surface in the Sahara Desert, either by natural flow or by pumping, and create most fertile oases. These are carefully cultivated and support a surprisingly dense population.[17] Their scattered locations make possible the caravan routes which cross this great desert from oasis to oasis. Millions of date trees yield the chief crop, both supply crop and money crop, of all this region. The French Government has built railroads across the fertile agricultural plain which faces the Mediterranean, through the Atlas Mountains, with their pastures and cork forests, down into the oases in the Sahara itself. Biskra quickly became one of the great date markets when it became the terminus of one of these roads. Caravans brought dates there from many other oases, and they were shipped by rail to Mediterranean ports.

The date grows through the desert parts of North Africa and western Asia as far as Mesopotamia. It is the chief export from the little independent Sultanate of Oman in southeastern Arabia, whose arid coasts look like the desert itself and whose population and products are to be found in the irrigated gardens of a few inland valleys where the date tree enables the Arabs to have food and also purchase the goods left at Muscat by the steamships from

[17] The date may well be called the king of crops. Certain oases are known to have been in continuous production for 2,000 years. Apparently desert dust or some other mysterious source feeds them. The date crop yields many times as much food as wheat. Beneath the date trees grow apricots, figs, olives. Beneath these lesser trees there is enough light to grow beans and many vegetables, giving a three-story agriculture and making it very natural that the writer of the allegory of the Garden of Eden should have chosen a date oasis to be Eden.

England, France, Germany, Italy, and America.

In Iraq (Mesopotamia), a land of aridity and oases, the date, as in Morocco and Algeria, is one of the important food products. Date trees line the Tigris for long reaches as far up as Bagdad. Mesopotamia is at the present time the chief source of the world's commercial supply. Basra is the port of shipment.

Introduction of the Fig and Date to the United States. The date tree, like the fig and the olive, has been found to grow well in southwestern United States, where the climatic conditions re-

The introduction of the date from the oases of the Sahara to the oasis of the Imperial Valley, southeastern California, is one of the spectacular things in American horticulture. The Imperial Valley is a true oasis with a true desert climate, therefore admirably adapted to the crops of the oases of the true desert, the Sahara or Great Desert.

The big bunches of fruit are visible on this full-grown tree—full grown except that year by year the trunk will get longer because it never produces two leaves in the same place. As one leaf comes off, a bit of bare trunk remains and other leaf comes on at the top. Thus the date palm reaches upward until at last a great height is reached and the tree can go no higher.

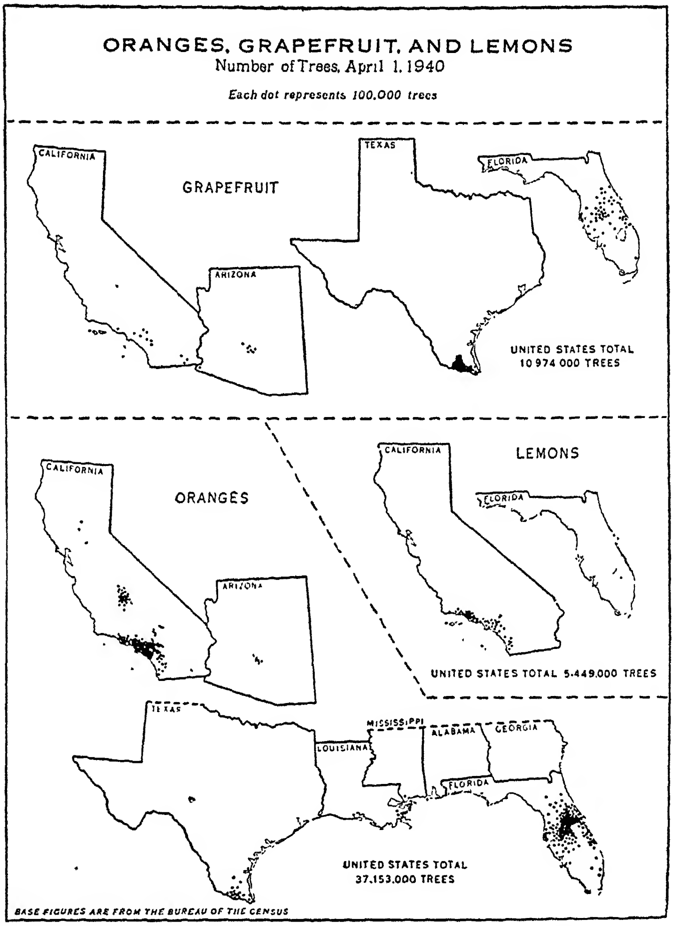
semble those of their old home in western Asia and North Africa. As with the fig, date culture has definitely passed out of the experimental stage in the United States. Prior to the war we imported about 23,000 tons of dates a year, and in 1943 our date production reached a peak of 10,500 tons, most of our dates being grown in the desert regions of the lower Colorado Valley and nourished by water from that river. American growers are concentrating on the very finest grades which are put up in attractive packages and are sold for several times the price of the cheap bulk dates shipped in from the Persian Gulf. Since 1936 our fig imports have been less than 3,000 tons a year, in contrast with our huge California output of 133,000 tons. About one-fourth of all California figs are dried, the remainder being sold either fresh or as a canned or preserved product.

Each Continent Has a Natural Dried Fruit District. Since each continent has its region of winter rain, summer drought and irrigation, there is world competition in dried fruits as other countries of the world become better developed. In the Australian state of Victoria, for example, the well-known irrigation colony of Mildura on the Murray River has under irrigation 500,000 acres of land under the same kind of arid climate that prevails in California, Spain, and Asia Minor, and the people are already producing prunes, dried peaches, dried apricots, dried currants, and raisins for the Australian market, and occasionally exporting to Great Britain, where they compete with the products of the Mediterranean countries and California.

South Africa has an increasing dried fruit industry, the principal fruits being raisins, prunes, dried peaches, dried apricots, and figs. The production of raisins has grown rapidly in recent years, the chief export market being Great Britain. Chile has her California on the plains and irrigated fields near Valparaiso and Santiago. Over the Andes from these Chilean orchards are the foothill settlements of San Juan and Mendoza in Argentina which are somewhat comparable to the Lower Colorado Valley of Arizona, producing raisins, dried fruit, and wine for that country. The South Americans have as yet done nothing worth mentioning in export, but, as in Africa and Australasia, the natural resources are there, awaiting the labor and care of the husbandman.

10. The Citrus Fruits

The Difficulty of Transporting Tropic Fruits. The citrus fruits, including the orange, the lemon, the grapefruit or pomelo, the tangerine, the lime, and several others of small commercial importance, are the advance guard of the tropic fruit supply. People of the north temperate zone are enabled to have these fruits on their tables because of the tough, thick, oily and bitter skin which serves as an effective protection against insects, bruises and decay, while a host of delicious tropic fruits remain practically unknown to commerce because they lack such natural protection and could not enter commerce until recently, and have not yet had time to develop markets and techniques of commercial production. What the airplane will do to remedy this condition remains to be seen. It is now possible to bring many of these tender tropic fruits, as,



These maps show several things to be explained by the careful student.

for instance, fresh pineapples, to temperate zone cities and the chief deterrent of large traffic in many others is the lack of demand resulting from our ignorance of them. The natural conservatism with regard to new articles of diet is surprisingly strong, but may be expected to diminish and permit the gradual introduction to our markets of many new southern fruits. The Japanese persimmon and the mango,[18] good examples of this, are already arriving in small quantities. The avocado production, 23,000 tons plus 5,000 tons from Cuba, may be said to indicate that this fruit has arrived.

The Orange. The orange is a native of southern Asia, possibly China, where, as in India, it has been used for many centuries. It was brought by the Portuguese to Europe in 1458, and became the basis of an important industry there,

[18] The mango, a delicious fruit as much used in the tropics as we use the apple and peach, is cultivated in India to the extent of a hundred named varieties. We could easily get them from the West Indies if the demand existed.

as it has become within recent years in the United States. The orange grows throughout the tropics and on the edges of both temperate zones, and is everywhere much prized by the inhabitants of those lands. Like many other trees it produces its finest fruits near the colder limit of its growth, so that the fruit of the United States is superior to that of the West Indies. It is to be had at almost all seasons of the year, since an orange tree carries ripe fruit and green fruit at the same time that it is in blossom. Continuity of supply is further aided by the growth of oranges in three climate types—tropic, humid subtropic, and Mediterranean. Its wide distribution makes possible an almost unlimited production, but inasmuch as the fruit is quite bulky and its commercial handling expensive, like the banana, it can only enter into commerce in large quantities where transportation facilities are of the best. Consequently, while it is important in commerce, the world's great supply is from a few localities readily accessible to the world's great markets. Oranges frequently waste even in such nearby places as Jamaica and the other West Indian Islands, whence it is almost impossible to get a profitable outlet for them except in the very early weeks of the season.

Importance in Mediterranean Climate. It is in the Mediterranean countries that the citrus fruits first gave rise to great commerce. The combined warming influences of the Mediterranean Sea, the Sahara Desert, the Atlantic Ocean, and of mountains protecting from the north wind, make this the most northerly of all regions with climate warm enough for these fruits. A short distance away are the millions of people of northern and western Europe, connected with the orange lands of the South by steamer and numerous railroads.

The three peninsulas of Europe which project far south—the Iberian, the Italian, and the Grecian—are all important citrus producers. The orange is found on the west coast of Portugal as far as 40° north. Orange districts skirt the southern and eastern coasts of the Iberian Peninsula, but the interior is too high and cold for this fruit except in the plain of Andalusia. The most important Spanish orange-growing district is on the irrigated plain of Valencia, near the central part of the eastern coast. The steamship lines that skirt this coast carry thence to Great Britain over two-thirds the orange supply used in that country. Much British marmalade is made of Spanish oranges. Spain is by far the heaviest exporter of oranges in the world, normally shipping about 25,000,000 boxes a year.

The citrus industry is nearly as important to Italy as it is to Spain, Italy possessing an orange or lemon tree for every two persons in the whole country. Although the orange reaches its highest northern latitude for the world, 44°, on the protected coast of Italy not far from Genoa, it is not important north of Rome, and the lemon, being more susceptible to cold, will not grow north of Rome at all. The Italian orange export was 4,200,000 boxes in 1938.

Oranges, mandarins and lemons are grown in Greece, but the export trade is not important.

The French colonies of Algeria and Tunisia are the leading citrus growers

of the north coast of Africa, France receiving a large part of her orange supply from Algiers, the center of production being near the port of Oran. Palestine at the east end of the Mediterranean ships through the port of Jaffa over 10,000,000 boxes of oranges every year, most of which go to Great Britain.

The Importance of Islands in European Citrus Fruit Growing. It is upon islands that the growing of citrus fruits seems to reach its most extensive development in the Mediterranean chiefly because the surrounding waters afford frost protection. Majorca grows them. Malta has long been known for the excellence of its oranges, while in Sicily and the neighboring shores of Calabria we have the greatest development of the Italian orange and lemon industry. Sicily greatly predominates over the mainland in both these fruits, having almost a monopoly of the production of lemons, whence they have for a century been distributed to the lemon-consuming regions of Europe and America. The Italian and Sicilian peasants give these fruits the greatest care. South of Naples they can only be grown in those few spots that can be irrigated. The ground is usually cultivated with the hoe and the spade, garden crops are often grown between the trees, and much of the soil is so steep that it is kept from washing into the Mediterranean only by the laborious building of terraces restrained by stone walls. It is chiefly this intensive kind of agricultural industry that has given to rugged and arid Sicily a population of 403 persons to the square mile. Citrus fruits usually account for more than two-fifths of all Sicilian exports.

Citrus Fruits in Asia. Although Asia is the native home of the orange, its culture has not been as highly developed as in North America and Europe. While grown successfully in most parts of subtropical Asia from the Mediterranean to the China Sea it rarely enters into commerce. The Japanese are vegetable rather than meat eaters, and they consume less fruit than do the Western peoples. Southern Japan is producing the equivalent of eight million boxes of citrus fruits a year, principally mandarins and grapefruit, of which a few have come to the United States. Throughout south China various citrus fruits are grown, the tangerine and other loose-skinned varieties being favored.

New Citrus Lands in the Southern Hemisphere. The fruits of the southern hemisphere have the immense advantage of ripening at about the time when those of Europe and the United States have been consumed. South Africa has a climate belt of the Mediterranean type, grows fine citrus fruits, and is now shipping about 400,000 boxes of oranges to Great Britain each year. The orange is equally successful in parts of Australia, but the Australian orange has not as yet played much part in world trade. The increasing ability of the new countries of the southern hemisphere to put fruit on the market during the European summer, however, is already causing alarm among the Italian and Spanish export growers.

In South America the greatest commercial production of citrus fruit occurs in Brazil. It is estimated that Brazil has more than 20,000,000 bearing trees, predominantly oranges, which are concentrated largely in the states of São Paulo,

Rio de Janeiro, and Minas Geraes.[19] Between 1921 and 1939 the Brazilian orange crop increased from 2,200,000 to 35,700,000 boxes, and exports increased from 99,000 to 5,600,000 boxes. About 40% of Brazilian orange exports are destined for Great Britain, and about 40% are sold to Argentina, most shipments being made through the ports of Rio de Janeiro and Santos. Elsewhere in South America citrus possibilities are largely undeveloped. Far up the Paraná River in Paraguay oranges are regularly used for fattening hogs, and it is only from the districts adjacent to steamboat landings that they are exported downstream to Argentina and Uruguay. These countries have in Paraguay a subtropical garden spot whence they derive, as does Pennsylvania from Florida, fruits and vegetables of a warmer clime. The central valley of Chile, a South American California, has a local production of oranges and lemons.

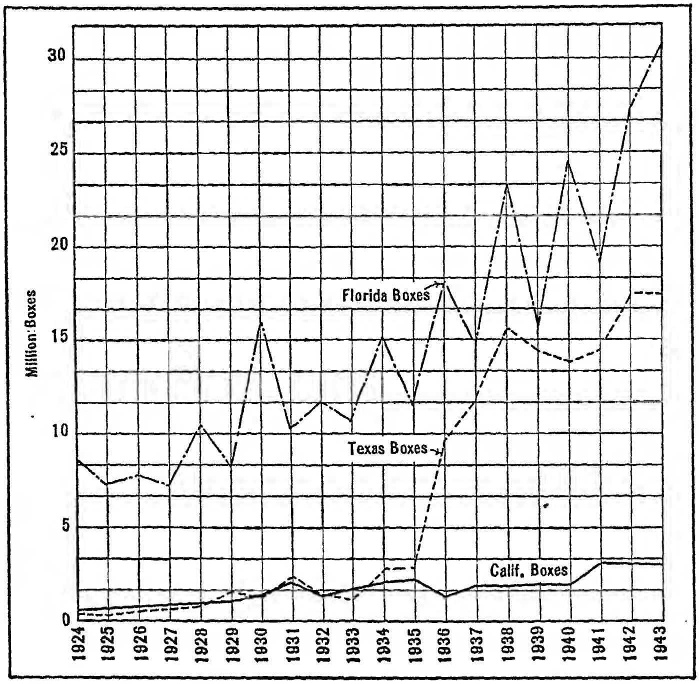
Citrus Fruits in the West Indies. Throughout most of the West Indian islands and in Central and South America along the borders of the Caribbean, oranges, lemons, limes, and other related fruits grow easily and are cheap and abundant in every local market. As a commercial crop for northern lands they are but little used.

The fear of frost destruction in Florida caused a boom in orange planting in Cuba immediately after 1899 when Cuba became independent. Orange and grapefruit groves were planted, chiefly by Americans, at an expense of $10,000,000, but the tariff and shipping costs leave so little money for the Cuban growers that there seems to be small prospect of large orange shipments from that island to the United States, or to Europe with its Mediterranean supply. The Cuban orange seems, like the Jamaican orange, destined to lie upon the ground rather than enter into foreign trade unless calamities overtake Florida and California, or the manufacture of orange products takes unwonted strides.

The lime, excepting the new kumquat, the smallest of the commercial citrus fruits, does best in the tropics and the chief supply comes from the Lesser Antilles. The leading producer is the little island of Dominica (Leeward Islands), where the fruit is grown on the steep, rocky limestone hills. From 50,000 to 100,000 boxes of West Indian limes are shipped to the United States each year. Here are plantations and factories owned by the great candy manufacturing firms of Europe who import lime juice and lime oil for use in their products. The neighboring island of Montserrat also produces limes.

The Early Import into the United States. This country began to import oranges from Italy and Sicily, where the industry had long been established, about 1835, when the American sailing vessels were perfected to great speed. With the development of the steamship, this import became large and regular and the West Indies also participated in the supply, the chief sources being the nearby Bahama Islands and the British colony of Jamaica. As a result of the tremendous expansion of citrus production in this country during the present century, our imports of oranges,

[19] The state of Bahia, long famous in Brazilian orange history, has only 400,000 trees.—See Brazilian Ministry of Foreign Affairs, *Brazil 1939/40: An Economic, Social and Geographic Survey,* Rio de Janeiro, 1940, pp. 119-122.



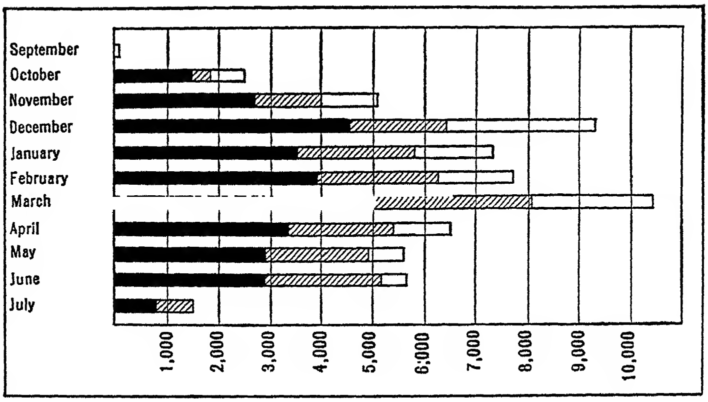
This map shows plainly that the regions of humid summer suit the grapefruit better than does the land of dry summer. Texas is a newcomer in grapefruit, but this graph shows how it has boomed.

grapefruit, and lemons have virtually vanished.

The Development of Citrus Production in Florida. Although the orange and grapefruit were grown in Florida by the Spaniards more than three centuries ago, it was not until the building of railroads and the establishment of through train service between Florida and the north in 1886 that citrus fruits became a commercial crop. The planting boom which followed the railroads spread also from Florida to the adjacent southern states. It is possible to grow good oranges throughout much of the Gulf region, but there is always the danger of a cold wave coming from the center of the continent. If not in rapid growth at the time, the orange tree can resist some frost, but the warmth and moisture of the Gulf region may make the tree grow rapidly at any time during the winter. As a result, freezes soon destroyed most of the commercial orange groves in Georgia, Alabama, Louisiana, and Mississippi.

Before 1895 the commercial groves of Florida were located mainly along the St. Johns River, where a frost sometimes spoiled a crop without damaging the trees. Two severe cold waves in the winter of 1894-95 ruined the orchards in most of the state by killing the trees down to the ground,[20] and another kill-

[20] Citrus production figures tell the story of the catastrophe: 5,055,000 boxes in 1893-94, 2,808,000 boxes in 1894-95, and only 147,000 boxes in 1895-96.



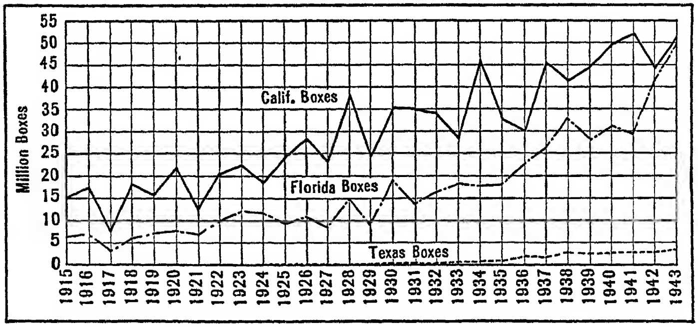
Movement of oranges from Florida during the 1938-39 season in carloads or equivalent: solid bars, rail shipments; crossed bars, sea shipments; open bars, truck shipments. The monthly distribution shows plainly that Florida is not a late summer and early autumn shipper, but a distinctly winter shipper. (Data from Florida State Marketing Bureau.)

ing frost followed in 1899. Commercial production was abandoned in the St. Johns Valley, and the industry moved south to lands with greater immunity to frost. Today more than 70% of the citrus acreage is located in the central part of the state on rolling uplands with the advantage of air drainage and where the presence of more than 4,000 lakes tempers the occasional cold north wind and reduces the hazard of frost.[21] The remainder of the Florida citrus acreage is concentrated around Tampa Bay on the west coast and in the Indian River Valley on the east coast where the warming influence of the sea is generally effective. Some of the growers keep oil heaters in their groves, or piles of wood ready to be ignited at the approach of a cold wave. In the central lake region orange groves line the highways like cornfields do in Illinois or Iowa. Citrus exchanges and packing houses are found in every small town, and most of the crop is shipped to the North through the central marketing agencies. The Florida orange crop of 1943 totaled 46,000,000 boxes.

Florida is the leading producer of the pomelo, better known as the grapefruit. The grapefruit production of Florida in 1943 amounted to 31,000,000 boxes, or about three-fifths of the nation's supply. About 4,000,000 cases of canned grapefruit segments and juice are marketed each year. The tangerine and other kid-glove varieties are also grown all through the Florida citrus belt. In 1943, Florida produced 3,600,000 boxes of tangerines and 190,000 boxes of limes. Lemons and limes do not meet with as much favor in Florida, being delicate and easily frosted. The lemon can be commercially grown only in the warmest sections of the peninsula, as the trees are subject to great injury when the temperature falls below twenty-eight degrees.

The California Citrus Industry. Florida's misfortune in 1894 proved to be

[21] Warren Strain, "The Florida Citrus Crop," *Econ. Geog.*, vol. 18, January, 1942, p. 17.



Orange crops in our three leading commercial states. The excellence of Texas in grapefruit does not appear to be duplicated in oranges. The rivalry between the two great leaders—Florida and California—is plainly visible.

California's advantage. The northern limit of the orange in Florida is about 30° north latitude while, in California, owing to the oceanic climate of the Pacific Coast, the tree grows as far north as 37° in the southern part of the Great Valley. However, the region in which the industry has had nearly all of its large development is south and west of the Coast Range in the Los Angeles-San Diego district of southern California. Southern California has a destructive freeze about once in every 10 years. That of 1937 did $50,000,000 worth of damage, or about half the value of the crop.

California oranges are grown with the most perfect care on irrigated land of high value, the orchards often being valued at $2,000 and more per acre. This very high value is due not to scarcity of land but to scarcity of water, which amounts to scarcity of orange land, since unirrigated California lands cannot grow fruit. Great pains are taken to get and save water for the irrigation of the California fruit orchards. Tunnels are sometimes dug back in the hillsides to strike the underground flow, wells are dug and pumps lift the water to the land where it is often carried in cement pipes and put around the base of each tree so that the smallest possible amount may make an acre prosperous. Today the citrus orchards of the Los Angeles Basin are receiving water conveyed by aqueduct tunnel and pump from the Colorado River 300 miles away. The great distance from the eastern market makes transportation costs high, so that only the best fruit can be shipped. To attend to these matters the fruit growers have formed associations which are good examples of cooperative enterprise. In 1943 California produced 51,000,000 boxes of oranges, or nearly half of the nation's total crop, 12,000,000 boxes of lemons, and 3,000,000 boxes of grapefruit, most of which was shipped by rail to the great urban markets of the East.

The Lower Rio Grande Citrus Industry. The principal development in recent years has been the rapid rise of citrus production on the irrigated lands of the Lower Rio Grande Valley of Texas. The first shipments were made to northern markets in the winter of 1921-22, and in 1943 this valley produced 17,500,000 boxes of grapefruit and 3,400,-

000 boxes of oranges. This region has a slight climatic advantage over its competitors, for the U. S. Weather Bureau records show that on the average there are only 3.5 days out of the year with freezing temperatures at Brownsville, Tex., 5 days at Eustis, Fla., and 12.9 days at Redlands, Calif. The sweet Texas grapefruit, with its pink meat, has already won great favor among American consumers.

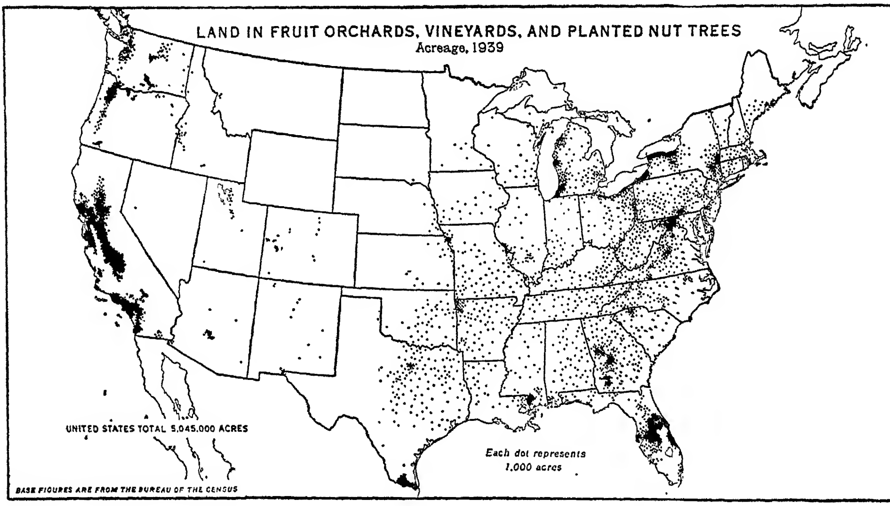
Today the citrus industry of the United States meets all domestic demands for oranges, grapefruit, and lemons and has a sizable surplus for export, chiefly to Canada and Europe. Keen competition exists between the great citrus regions of Florida, California, and Texas, and the recently developed citrus district in the irrigated Salt River Valley of Arizona. The major problem confronting citrus fruit producers is the danger of overproduction and low prices, a danger that hangs like the sword of Damocles over the entire fruit and vegetable industry and almost everything else that does not have some kind of monopoly control.

11. The Grape and Wine Industries

History and Requirements of the Vine. The grape outranks all other fruits in literature, romance, intoxication, and in sober gustatory delights. These factors have combined with its importance in classic lands to make the grape the most celebrated of fruits even back to the day when Noah relaxed after bringing his ark to port with its precious and varied cargo. The vine is indigenous in eastern United States and from Hungary to Afghanistan in Eurasia. Grape seeds are to be found in the remains of the Swiss lake dwellings dating back to the Bronze Age, but it is probable that the Old World industry as we now know it began somewhere in western Asia. Old Testament references to the vineyards show its high antiquity among the Hebrews. The grape was early introduced among the Greeks and Romans and has spread throughout the world wherever the climate and soil permit of its cultivation and even beyond the natural climatic bounds, for large quantities of most delicious and expensive grapes are produced in the hothouses of England, Holland, and France.[22]

The chief requisite for the grape is a summer of considerable heat lasting into September. The vine sends its roots to great depth and can thus search out water in arid soil and will thrive in dry climates when most surrounding vegetation is brown and dead. Thus, it grows in southern Italy and other Mediterranean lands without irrigation on the hills above the orange groves. In California, which is a relatively empty agricultural frontier in comparison to Mediterranean lands, the grape is usually irrigated. This is merely because pressure of other crops for the water has not yet pushed the grape up on the hillsides, above the water line (where it yields, but less abundantly), as has happened in the Old World. Accordingly, the grape is at home upon the edge of the world's subtropic belt in each of

[22] In England the growing of fancy grapes in hothouses is largely localized in Sussex County. The season for marketing opens in May and during the early selling some of the best grapes bring as high as 30 shillings per pound.



This map, showing all the land in all the fruits and nuts, gives a good place for the reader to test his knowledge.

the three continents of the northern and southern hemispheres. Too much moisture is detrimental, producing fungi which attack and destroy both the leaves and the fruit. Thus the monsoon climate of India, China, and Japan with its great summer rain makes extensive grape growing impossible, and our southern states follow suite.

The Limits of Grape Growing. Although the grape is grown on the sheltered Channel Islands, the line marking the limit of the industry on the mainland is curved from the west coast of France near the mouth of the River Loire northward to latitude 53° in east Germany. This northward trend is due to the increasing heat of the summer as we go eastward from the moderating influence of the ocean into the greater heat of the continental summer. In Russia the summers, though hot, are shorter and the grape line descends to the Sea of Azof and thence runs eastward through south Russia and Asia. In America, there is a similar bend of the grape limit from 37° north in California to 40° in south Ontario where the lake belt gives grape growing a northward extension. In the southern hemisphere grapes grow in the Mediterranean climate areas in Australia, South Africa, and temperate South America. Before the coming of extensive and easy commerce in wine, grapes were grown and wine was important in the valley of the Severn in England, and in parts of Germany above the present line, but the quality was poor, the harvest uncertain, and the industry is now limited to districts of more favorable climate.

Importance and Difficulty of Transplanting the Industry. Grape growing and wine making reach their greatest importance as a national industry in France, Italy, and Spain—countries which produce five-sixths of the world's wine. Other countries of importance are Austria, Russia, and Switzerland. But

through all the wine-growing countries, thence to Algeria, and finally reached South Africa, Australia, and South America. The phylloxera, a tiny insect of the aphis family, gets upon the roots of the grape vine and sucks the juices from them until the vine is killed. No

The map of wine-producing areas in France shows that the northern part of the country is too cool. Most of the vines are in valleys, usually on the southern slopes of hills. The names of the various centers are printed on the map.

cure has been found, and France, which had nearly 6 million acres in the vine in 1863, had less than 2 million acres of healthy vine in 1885, and another million acres invaded by the phylloxera. The only thing which prevented the practical extermination of grape and wine growing throughout the world was the fact that in America, the home of the phylloxera, there were varieties of grape immune to its attacks. These were imported to Europe, set out by millions in the vineyards which the phylloxera had devastated and tops of the European varieties were grafted upon their roots, making a composite plant with American root to resist the destroying insect and a European top to produce the desired wine grape. Thus, the industry rose again until, at the present time, France has about half as many acres in vines as she had in 1875.

While French wines are consumed throughout the world wherever the people wish to drink the best of wine, the French themselves are large wine importers, taking practically the entire crop of Algeria, which is one-third as great as that of France, and getting also large quantities from Italy and Spain. Sometimes they sell their own high-priced wines and use the cheaper wines of Italy and Spain for home consumption. Much of the import, however, they mix with native wines and flavor, label, and export as French wines. They even import dried currants from Greece, which are manufactured into wine for export. Germany also imports these currants for the purpose of enlarging the output of her choice brands of wine, and even apple chop, the cores and skins and small apples dried in American apple plants, is said to be elevated to the higher life and finish its career as European wine.

Spanish Grape and Wine Industry. Spain, the third great wine-producing country of the world, is also a grape exporter, sending to Great Britain, especially from Malaga and other southeastern ports, 3 to 4 million dollars' worth of grapes each year when business is good. In 1891, before the phylloxera had done its work in Spain, wine made up one-third of the export from that country, but now the proportion is only about one-ninth, although wine is still

the leading export. The best-known of Spanish wines is the "sherry" which, since the time of Shakespeare, has been exported from Jerez de la Frontera, a town near Cadiz. Jerez has been corrupted into "sherry." Portugal, which resembles Spain in people, resources, climate, and industry, has one-twentieth of its total area in vineyards, and wine which goes chiefly to Great Britain and Brazil makes up over one-fifth of the exports of the nation. Port wine (derived from Oporto) is the leading brand.

Hillside Grape Growing in Europe. In the northern parts of the European grape belt the desired heat and sunshine can be obtained by planting the vineyards on the southward-sloping hillsides. In this way they are protected from the north winds and exposed, by the inclination, to the nearly direct rays of the sun, and often get in addition the reflected sunshine as from the surface of the Rhine, the Moselle, and the Swiss lakes.[28] By this means Switzerland has become a wine producer, utilizing the slopes overlooking Lake Geneva and the other Swiss lakes, the Swiss wine output amounting to about 12,000,000 gallons a year. Germany, with a production less than one-twentieth that of France, is perhaps the best example of hillside grape growing. The most famous of the German districts are upon the steep south slopes that come down to the Rhine, and its tributaries, the Neckar and the Moselle.

The vineyards upon these riverside slopes prosper in latitudes where otherwise they would scarcely exist. Some of the Rhine terraces have been in grapes continuously for centuries, and so highly prized have certain brands of wine become that new terraces have been built from time to time in places so forbidding that a retaining wall had first to be built and earth carried up from the river bank (often by women), before the vines could be planted. One particular mountain slope near Bingen produces the most famous Johannesberger wine and some years ago was valued at $7,000 per acre, the equivalent of $33 per front foot for a building lot 185 feet deep. These terraces, so steep that horses cannot be used, are cultivated entirely by hand, even to the carrying up of baskets of manure, strapped upon the backs of men and women. So dense is the population of these districts and so great the pressure upon resources that when the green ends of the vines are cut off in August to hasten the ripening of crops, they are carefully saved and fed to the goats, and when the vines are trimmed in winter the cuttings are sold for fuel.

Owing to the scarcity of land, terrace vineyards are common on Italian hills and mountains. Nearly 200 terraces, one above the other, may be seen on the southern slope of the Apennines, near Lucca.

Spread of Wine Growing to New Countries. There have been many attempts to establish wine growing in other countries, but for reasons already stated the progress has been surprisingly slow when we consider the vast areas in North and South America, North and South Africa, Australia, and Asia that are probably as well suited to wine making as is Europe. The growth of sheep, cattle, and grains springs up in a new

[28] It is interesting to find the same kind of hillside grape growing developing in the northern limit of the American grape area along the shores and islands of Puget Sound in Washington State.

country in a decade, but the amount of capital, labor, and skill required for making wine, combined with the even greater handicap of a new brand, leaves the three original wine-growing countries overwhelmingly predominant. The colonies and frontiers may produce the bread and meat, as for decades they have done, but all of the colonies of Great Britain combined do not produce one-half of 1% of the world's wine. Rumania and Russia, possessing the dense population to supply the necessary labor, have made greater progress in the last sixty years than any colony. Both have had a small wine export in favorable years. Grapes thrive in Turkey, Asia Minor, Syria, Persia, Turkestan, and other parts of western and interior Asia, where travelers and explorers frequently find them of excellent quality and of local use, but not yet affording a basis for any commerce.

Australia. Australia has large vine-growing areas near her arid interior and it is admitted by some experts that the product of some of the Australian vineyards is practically as good as any wine in the world. Imports of wine decreased rapidly with the expansion of the local wineries and some is now exported, mainly to the Pacific islands. South Australia is the leading grape state and wine producer, followed by Victoria. In New South Wales the farmers have been driven to grape growing because the droughts, although they ruin the wheat, will not prevent a crop of grapes. In addition to wine making the grapes of South Australia and Victoria are going increasingly into raisins.

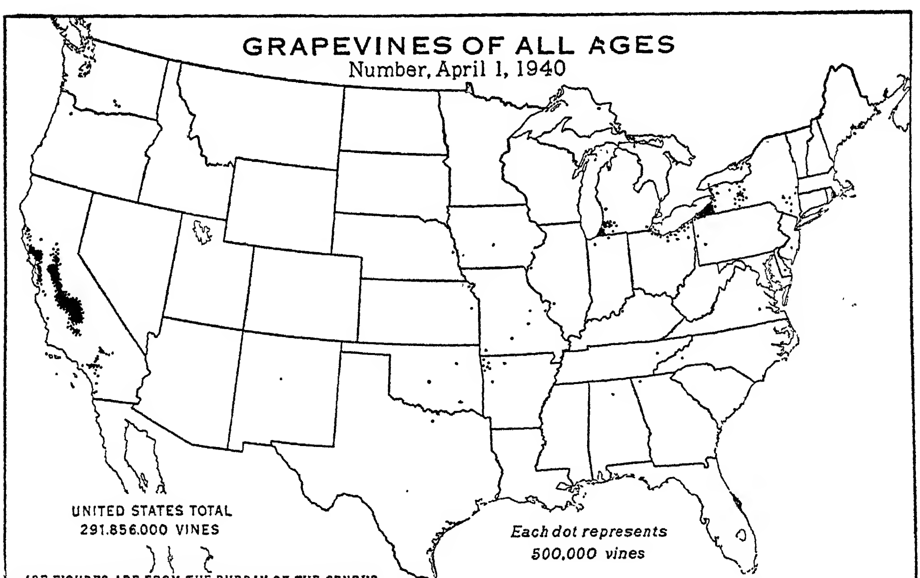
South Africa. South Africa seems to have, in the western part of Cape Colony near Capetown, just the right conditions of soil, sunshine, and moisture to make it one of the best grape-growing regions in the world. The Dutch settlers succeeded well with French and Rhenish vines, and in 1822 this region sent more wine to England than did France. The fungus and insect pests of the nineteenth century, however, have kept the industry down and the present production is less than that of Australia and very small in comparison with France and Italy. The ripening of the fruit in the springtime, when we have nothing but expensive hothouse products in northern latitudes, causes the export of some fine grapes to Great Britain along with the peaches and plums previously mentioned. There seems to be no reason why the fresh grape trade to the northern hemisphere should not assume large proportions.

South America. South America has its grape districts upon the edges of the desert belt which cuts diagonally across the continent from northern Chile to southern Argentina, between the eastern rain belt of the trade winds and the western rain belt of the westerlies. Chile is a large consumer of wine, and the local production often amounts to about 18 gallons per capita. This is grown on an area half as large as the German vineyard area, and located in the northern part of the Great Central Valley of Chile, a region supporting most of the agriculture and population of that country, and much resembling the Great Valley of California. Near Santiago there is a splendid plain given over to intensive culture by irrigation and to the growth of grapes which are made into a wine of local fame. Chile has a small export of wine but, as from all

other new wine regions, she has to meet the difficulty of convincing wine users that her output is as good as the established brands of Europe.

In Argentina the chief grape and fruit districts are dominated by French wine growers in the irrigated settlements of Mendoza and San Juan, watered by snow-fed streams from the nearby Andes and separated from the agricultural plains of the east by some hundreds of miles of arid sheep and cattle ranges. Special trains carry fruit and a large part of the wine to Buenos Aires, the largest city in the south temperate zone and in population a rival to Philadelphia. Argentina's wine output of 294,000,000 gallons is more than double that of Chile. Uruguay also has some wine production, but like that upon the coast settlements of the Peruvian desert plain, it simply serves a local need. Some European wine is imported by every country of South America.

Grape Growing in the Eastern United States. When the European colonists landed upon the shores of the United States and stocked their gardens with the plants and trees of Europe they were pained to find that all the grapevines promptly died from some mysterious kind of blight that destroyed the leaves. It was fungi thriving in the heat and humidity of the eastern American climate, enemies to which the plant had never been subjected in cool west Europe or the dry summer of south Europe. Yet the colonists found in the American forests wild grapevines growing to prodigious size, climbing to the tops of the tallest trees and often reaching a thickness of half a foot or even more. From this stock plant breeders have in three centuries evolved a number of varieties



The map of grapevines shows one of the sharpest concentrations in American horticulture. The grapes will grow well over large areas in the eastern states, but exceptionally well along lake shores.

of edible grapes, their names, Concord, Clinton, Niagara, Delaware, Agawam, Catawba, Early Ohio, etc., showing their American origin.

The grape is widely grown throughout the eastern and southern parts of the country as a garden crop, but the cold waves of the continental climate with their late spring frosts seem to make it uncertain as a money crop except in localities where water bodies give frost protection. Consequently, the eastern grape belt lies close to the shores of Lake Michigan and Lake Erie, to a lesser extent to those of Lake Ontario, and to the five slender north and south lakes of New York, called the Finger Lakes. The vineyards of the Finger Lake district are upon the southern and western slopes of the hills along the eastern shores of the lakes, the prevalent west winds blowing across the waters in spring giving the desired temperature. The fact that New York state possesses the Finger Lakes and touches the two Great Lakes, Ontario and Erie, gives it leadership in eastern grape growing. Michigan, with a group of heavy grape-growing counties along the eastern shore of Lake Michigan, ranks second. Ohio with a long stretch on Lake Erie is third, and Pennsylvania with one county on the lake is fourth. All along the southeastern shore of Lake

A vine of Thompson Seedless grapes in a California vineyard. Of the total of more than 500,000 acres in that state alone, more than 1/3 are of this variety, which is used for raisins, for table grapes and to some extent for wine.

Erie, especially on certain islands in the lake and even on the Canadian lee shore, the grape field is much the most important field upon the farm and is often the entire dependence of the grower. The grapes of this eastern district are chiefly of the Concord and Niagara varieties which are much prized as table grapes and are widely shipped to the cities, small towns, and country districts of eastern and central states. They are far sweeter and cheaper than the edible grapes of central Europe. The American variety of grape makes very good grape juice and this industry is rapidly growing in importance.

California Our Leading Grape Grower. Although the European grape failed in the eastern United States it has succeeded remarkably in California, where it was introduced by the Franciscan fathers during the latter half of the eighteenth century. The earliest variety, now generally known as the Mission, was probably brought over from Europe in the time of Cortez. It was admirably adapted to the purpose of the missions, for besides being a good table grape which kept well and was not too sensitive for primitive methods of handling, it could be used for the making of sweet wine. Even after the American occupation of California, it was for many years the only variety in use. While well adapted to the climate and a prolific bearer it was susceptible to the inroads of the phylloxera and had to be grafted as previously described.

Fresno County alone has about 165,000 acres in raisin, wine, and table grapes. The Great Central Valley is comparatively level, in marked contrast with the vineyards of Italy and Switzerland, and the deep valley soil with irrigation gives a yield per acre greater than that of any other in the world. In 1943 California produced 94% of the nations' grape crop of 2,973,000 tons.[24]

In the Pacific coast states outside of California the growing of grapes is still largely experimental. In parts of Washington, Oregon and Idaho, European grapes of table varieties are giving very promising results in favored locations. The vines need some protection in the winter by covering them with straw or earth.

[24] In 1943 1,605,800 tons of California grapes were dried for sale as raisins, 790,000 tons were crushed for wine, 322,900 tons were eaten as table grapes, 57,300 tons were used for grape juice, and 13,000 tons were canned.—U. S. Dept. of Agriculture, *op. cit.*, p. 176.

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Sugar

Syed Iliyaz Mehdi – B.A. 60-61

1. Many Possible Sources

Is there any other food so widely liked and so widely used as is sugar? There are hosts of vegetarians, but the anti-sugarites have not yet appeared, except unwillingly, by order of the physician. Our children, our pets, and our domestic animals alike beg for it. As nearly all plants have sugar in their sap at some time in their growth, there are many sources of sugar. Many plants store sugar which can be used in other seasons, just as other plants store and use starch. All fruits have some sugar, the grape being especially rich, and a considerable portion of sugar is even found in the onion. The more important of the sugar-storing plants are beets, carrots, and parsnips, which hoard it for use in the second year of their growth to make their heavy top, blossom and seed. In the tropical zone the date palm, Palmyra palm, and coconut palm are all used to some extent for sugar manufacture in the lands of their growth. The American Indian got sugar from maple trees. The sugar cane, a plant much resembling an earless stalk of corn filled with sweet juice, grows throughout the moister parts of the tropics and in its natural condition was so superior to other sugar yielders that it was, save for the maple tree and the honey bee, practically the only source of commercial sugar supply until the nineteenth century. An exception should be made for the primeval sugar supply of honey (the sugar of blossoms), which was much more important in past centuries than it is since other and much cheaper sources of sugar have been developed.

The general and heavy use of sugar among temperate zone people is recent, and it has rapidly passed from luxury to a necessity. In 1589 a pound of sugar cost as much as a quarter of veal. In 1700, 50,000 tons per year were used in all countries of Europe. At the present time, that quantity lasts the United States about two and one-half days. There was a sevenfold increase in the world's commerce in sugar between 1815 and 1915, and most of the nations that can afford it are using more and more per capita each year.[1] The demand for sugar does not stop with the kitchen and the dinner table. Enormous quantities are used by the makers of candies, chocolate, jams and jellies, bakery prod-

[1] Sanborn & Company statistical report gives these per capita consumption figures 1939-40: Sweden, 126; United States, 98; United Kingdom, 94; Switzerland, 73; France, 59; Japan, 25; China, 3.

The luxury aspect of sugar shows in these figures—United States per capita 1938, 95.1 lbs.; 1941, 103.6. United States ice cream production 1937, 281 million gallons; 1942, when near every pocket bulged with war money, 462 million. War shortage cut our 1943 sugar to 80.3 lbs.—U. S. Dept. of Commerce, *Statistical Abstract of the United States, 1943*, Washington, 1944.

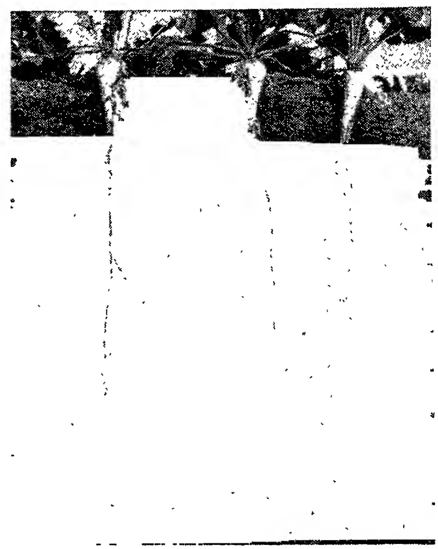
ucts and soft drinks, of which consumption in the United States, the world's largest consumer, is still increasing astonishingly.

2. *The Perfection of the Sugar Beet by Plant Breeding*

Sugar is one of the few commodities in which there is competition in production between the temperate and tropic regions. During the last seventy years, there has been a strong rivalry between cane-sugar producers and beet-sugar producers, and it will doubtless continue for decades to come.

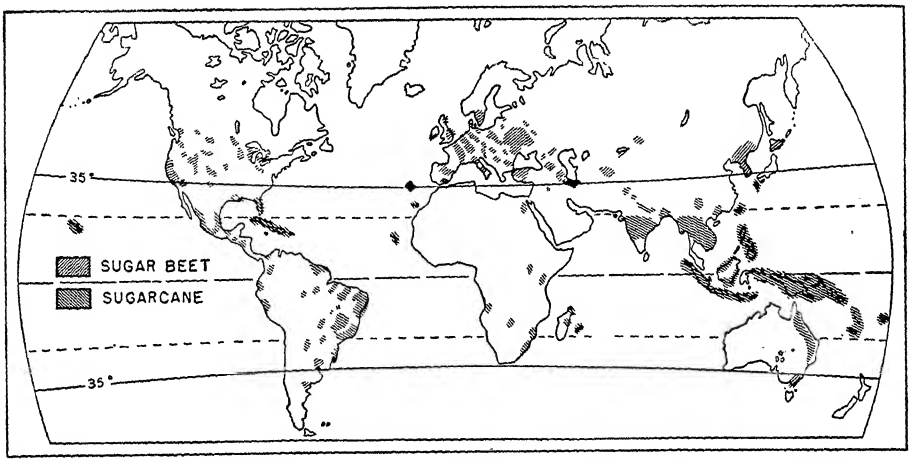
It is probably due to the Napoleonic Wars that the beet has become a great source of sugar supply. The military and commercial blockades of these wars cut off France and often the rest of Europe from the cane-sugar supply of tropic colonies. At the order of Napoleon French scientists examined hundreds of plants in the search for a promising sugar supply. Among them the grape and the beet were most seriously considered because of their high content of sugar, but industrial effort centered itself upon the beet which the Germans first used in 1799. In 1806 the French Government offered a bounty for beet-sugar production, and in 1811 Napoleon ordered 80,000 acres of beets to be grown for sugar. Only one sugar factory survived the Napoleonic Wars and the renewed competition of cane, but the industry lingered along until finally by the middle of the nineteenth century it had become firmly established.

The beet-sugar industry affords us one of the best examples of the service that science renders to man. In 1836 it took 18 pounds of beets to make a pound of sugar; in 1882 about 10 pounds sufficed; in 1924 about 7 pounds, in 1942, only six pounds yielded a pound of sugar. This great improvement has been brought about chiefly in Germany, where on large sugar plantations trained



The careful washing down of this specially made bank in a beet field reveals the surprising length of root that some annual plants can make, also the importance of a deep open soil, which is the nature of many alluvial plains. This explains the suitability of such lands for growing sugar beets.

scientists devoted their whole time to improving the sugar content of the beets. Samples were cut from the most promising roots and tested; the best beets only were saved to produce seed the next year, and so on for generation after generation, always selecting the best. This process of systematic selection has, within the life span of man, trebled the sugar content of beets and, along with improvements in the process of sugar extraction, made possible one of the great agricultural industries of the



There is much more land suitable for each of these classes of sugar, especially in Soviet territories, Africa and South America.

temperate zone.[2] The process of improvement has not yet ended.

Climatic Requirement. While the beet will grow in a very wide range of territory from the tropic nearly to the Arctic, the conditions for beet-sugar production are exacting—a moderate amount of spring and summer rain and a summer of moderate heat, but not too hot, and a cool, dry autumn. The crop should have a growing period of about five months, in a warm atmosphere, since long hours of daylight are necessary to produce a high sugar content. Corn-growing climates are in the main too warm in midsummer, but as the cool climates of England and Sweden suffice, it is plain that corn and sugar beets are seldom competitors for the same field. Irrigation, especially in America, gives the best conditions for beet growing and this rarely suits corn, because of the coolness of the arid night. In Europe the best region for beets is the great cool northern plain from Normandy to central Russia.

Relation of Sugar-beet Growing to Intensive Agriculture. The growth of the sugar beet is an intensive agricultural industry. It can be prosecuted only in fertile mellow soil, rich in lime, and neither too clayey nor too sandy, finely prepared, and plowed so deeply that a sub-soil plow must often follow the ordinary plow. Caring for the crop has

[2] Here is a suggestive report from the Utah-Idaho Company:

	1891	*1894*	*1942*
Acres of beets grown.......	1,500	2,850	7,472
Tons of beets produced....	9,960	32,694	1,090,167
Average yield of beets per acre, tons....	6.6	11.47	14.07
Per cent sugar in beets......	11.0	12.7	16.60
Purity of sugar, %.........	80.0	80.2	86.14
Sugar extracted per acre, lbs.	1,162	1,336	4,187
Sugar per ton of beets, lbs..	115	156	287.6

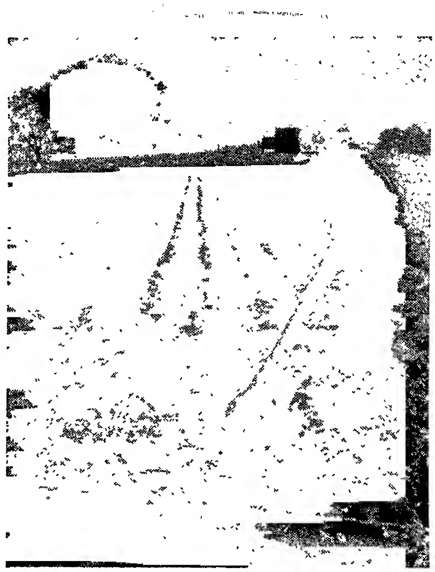
Source: Fred S. Taylor, *A Saga of Sugar*, 1944, p. 170.

been most laborious because of the large amount of hand labor required. The young plants grow naturally in such bunches that only human fingers can thin them and rescue them from the up-springing weeds, so that in the past men, women, and children, especially women and children, in nearly all beet regions, including the United States, spent days upon their knees weeding the young beets. A little later, when the plants had become established, they had to be thinned out with the hoe. But the Machine Age is coming to the beet field. American ingenuity has mechanized most beet-growing operations—a great triumph.[3]

After the plant is established there must be many cultivations, and in the late autumn the beets are plowed out of the ground and the tops cut off. The roots are then delivered to factories by wagon, train, or boat. The beet-sugar factory to be economical must be large, costing two million dollars or more. The beets are sliced, the sugar soaked out of them in hot water, and finally crystallized and sent to the refinery to be put into final form.

The by-products of the beet field serve to enhance greatly the usefulness of this crop in the intensive agriculture of a populous country. The tops from an acre of good sugar beets have a feeding value about equal to a ton of good alfalfa hay.

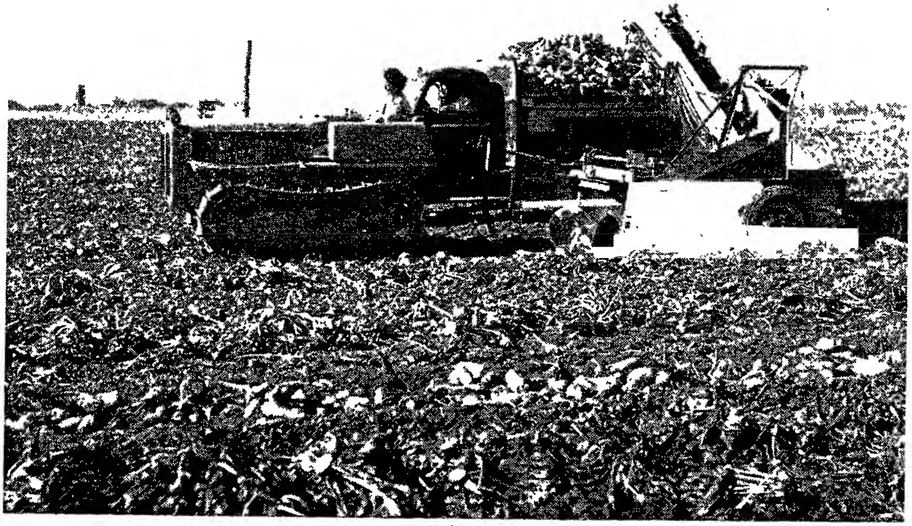
The pulp, a fibrous mass which remains after the sugar has been extracted, is taken back by the farmers and fed to cattle. It is also dried and shipped from the Rocky Mountain states to the Atlantic states for dairy cow ration. When these two feeds are properly balanced with grains, they will produce 200 to 300 pounds of meat per acre. Add two tons of sugar, and we see the intensive agriculture.



In the immediate foreground of this picture we see the water in the small field ditch from which the man with the shovel leads the water down between the rows. One of the great elements of cost in irrigation is that the ground really must be level or we have ponds and islands. The ponds flood the crop and make waste of water. The islands stay dry and the crop does not come.

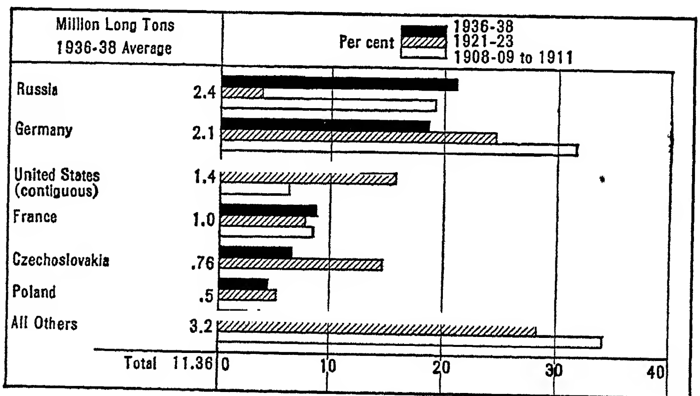
It is, therefore, plain that beet growing plays an important part in cattle-keeping agriculture, especially on the small farms of north Europe. The beet farms are almost universally well cared for, because the beet-manufacturing companies, to assure themselves an abundance of beets, insist in their contracts with the grower that a careful rotation of crops shall be followed.

[3] The story is too long to tell here. See pamphlet, "The Silver Wedge," U. S. Beet Sugar Ass'n, Washington.



A

Another of the triumphs of machinery. In the foreground are beet tops that have been cut from the beet by a machine, then a row of beets that has been dug by a machine. The woman drives the Caterpillar tractor which pulls the beet lifter, which has two small disks that throw the beets back to the conveyor that lifts them to a truck alongside. This Colorado field has 94 acres, making 20 tons of beets per acre—this beet loader loads 50 tons per hour, with less than one gallon of 6½¢ fuel per hour. In the background is a barn and silo. Cement silos now tower above a barn almost as smokestacks tower above a building.



B

Sugar-beet production, three-year averages at three periods, and tons for the last period, is not as clear cut as one would wish because of the changes in boundaries between the first and second period: Russia, Poland and Germany. The very low figure for Russia in 1921-23 is a measure of the political and economic chaos which then prevailed in that country.

Furthermore, the care and fertilizing required by the beet leaves the field in excellent condition for the production

TABLE 25

PRODUCTION OF LEADING CROPS IN GERMANY

	1937 (1,000's of bu.)	*1938 (1,000's of bu.)*	*Average for the two years*
Wheat	164,121	204,954	184,536
Rye	272,299	338,811	305,555
Barley	167,087	195,132	181,109
Oats	407,752	438,568	423,160
Potatoes	2,032,287	1,870,038	1,951,162
Sugar beets	15,701 †	15,546 †	15,623 †
Beet sugar *	2,184	2,370	2,277

ACREAGE OF LEADING CROPS

	Per cent of these six main crops in Germany	*Area (acres) (1,000's)*		*Average acreage for the two years*
		1937	*1938*	
Wheat	14	4,878	5,036	4,957
Rye	29	10,269	10,435	10,352
Barley	12	4,234	4,135	4,184
Oats	19	7,030	6,665	6,847
Potatoes	21	7,136	7,149	7,142
Sugar beets	3	1,125	1,240	1,182
Totals		34,672	34,660	34,664

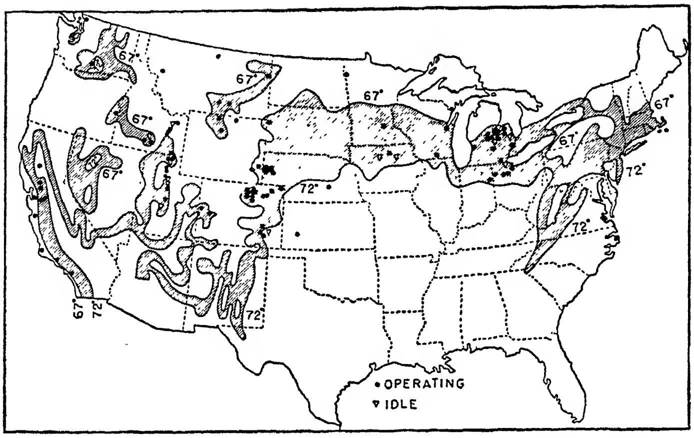
* Seasons ended following year.
† Metric tons.
Source: U. S. Dept. of Commerce, *Foreign Commerce Yearbook, 1939*, Washington, 1942, p. 48.

of a fine crop of small grain the succeeding year. This results in such increased yields of grain per acre that it is said that the addition of beets to the crop rotation has not reduced the total grain yield of the beet districts.

The surprisingly small acreage that produces the European beet crop is another proof of its fitness for intensive agriculture. Belgium, the most densely peopled of all western countries, has only 2% of her area in this crop, but has long been a regular sugar exporter. Germany, with the most fully developed agriculture of any of the large nations, was a heavy exporter in most prewar years, yet only 3% of her tilled land was in sugar beets.

European Centers of Production. The map of beet production (Fig. 522) shows that while its growth is scattered throughout central Europe from northwestern Spain to Moscow, there are centers of special importance. The greatest is in central Germany, near Magdeburg, where beets occupy from one-tenth to one-seventh of all the cultivated land. Here the beet fields spread in great expanses over the level, perfectly tilled plains, and while the peasant children pull weeds, their mothers may be seen plowing the beets, using at times the family cow for a draft animal. During the winter the manufacture of the sugar occupies much of the laboring population, and the by-products help to feed the animals on the farms. This district is well situated for export of sugar because it is on the navigable Elbe, which carries nine-tenths of the traffic in this territory. If Poland and Russia can again become normal, they will doubtless revive their great beet industry. Bohemia (Czechoslovakia) in the plains around Prague, on the navigable Elbe has had the greatest intensity of beet culture in all Europe.

The beet region of the Netherlands, Belgium, and the north of France between Paris and the English Channel is economically one region separated only



Location of beet-sugar factories in the United States. The zone between the mean summer isotherms of 67° and 72° F. is shaded.

It is easy on this sugar map to trace the edge of the Rocky Mountains in Colorado, Wyoming and Montana, and the western front of the Wasatch in Utah. This is a very clear-cut case of the confinement of an industry between rather narrow thermal limits. The two idle sugar factories in northern Iowa got too close to the Corn Belt to win out.

by political boundaries across which the beets are freely passed to the nearest factories without tax or duty. Since World War I, the United Kingdom abandoned free trade, put bounties on beets, and at the outbreak of the war her crop equaled that of Belgium and the Netherlands. The impoverishment of World War II will probably compel her to keep on. Southern Sweden and Denmark are also beet growers, and Italy has a crop unexpectedly large for her location and climate.

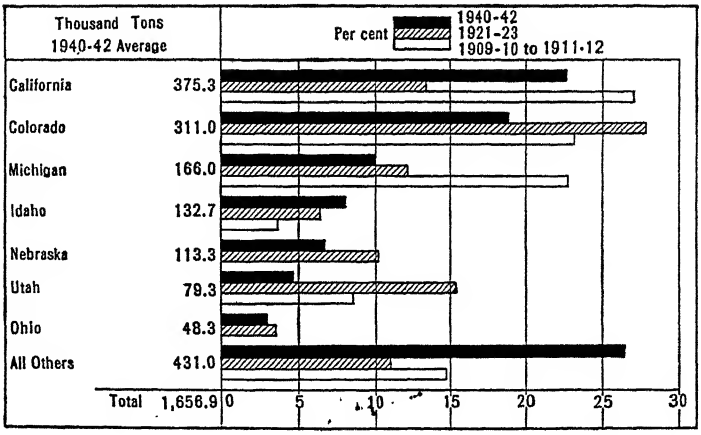
3. Governments and Beet Sugar

The beet sugar industry is one which seems to be especially tempting to interested politicians. They build up the industry in places where nature never intended it to be,[4] ~~and they~~ tear it down in places where it seems to thrive best. In both kinds of places they put it into the strait jacket of quotas and trusts, and the leading strings of special tariffs and bounties.

The sugar lobby is an active member of that large and active family of pressure groups which in the democracies sleepeth not. Most of the state and Federal laws regulating compensation, hours, and working conditions of wage earners do not apply to workers on farms.

An exception is the establishment of a minimum wage for sugar beet and sugar cane labor under the provision of the Federal Sugar Act of 1937. This Act provided for public assistance to producers of sugar beets and sugar cane. The benefits were granted by Congress under certain conditions. One of the conditions was the establishment of a

[4] For many years, the United States has had an import duty that kept our sugar industry from speedy death.



Beet-sugar production by states, three-year averages for three periods, thousands of tons for the last period, shows by the great fluctuations that this industry has not settled down yet to an established normal basis.

"fair and reasonable rate" of pay for workers. The determination of what is "fair and reasonable" is made by the Secretary of Agriculture after public hearings and investigation. Annual determination of minimum wage rates in the sugar-beet and sugar-cane industries have been made by the Secretary of Agriculture since 1937. The determinations are in considerable detail, the rates for the sugar cane being different from those of the sugar-beet areas, and the rates for the several sections varying with local conditions and customs. In the sugar-beet section, the wages range from 30¢ per hour to 45¢ per hour. In the sugar-cane sections, the wage range is from 13¢ per hour for female workers in Louisiana, to 22.5¢ per hour for males in Florida.[5] There are some other compensations in the cane-sugar sections, such as housing, gardens, wood, and the like.

The Sugar Act of 1937 levied an excise tax to provide the funds. It also established exact percentages for all of the various producing areas, together with a formula on the basis of which the Secretary of Agriculture is required to estimate probable consumption. These percentages, and the amounts which they represent in the 1939 estimate for total raw sugar consumption, are as follows:

Areas	*Per cent of total*	*Short tons*
Continental beet sugar	23.19	1,566,574
Mainland cane sugar..	6.29	424,914
Hawaii..............	14.04	948,456
Puerto Rico..........	11.94	806,593
Virgin Islands........	.13	8,782
Philippine Islands....	15.41	1,041,005
Cuba................	28.60	1,932,040
Other foreign areas...	.40	27,022
	100.00	6,755,386

In the last decades of the last century, European countries likewise fostered the beet industry with tariffs and sugar export by bounties. This made low prices and hard times in cane-sugar lands. To

[5] U. S. Bureau of Labor Statistics, *Handbook of Labor Statistics,* 1941 ed., p. 415.

protect her colonies, England threatened to lay on all sugar imported into that country a tax that would just equal the bounty that it had received in the export country. This would benefit the British treasury at the direct expense of continental treasuries.

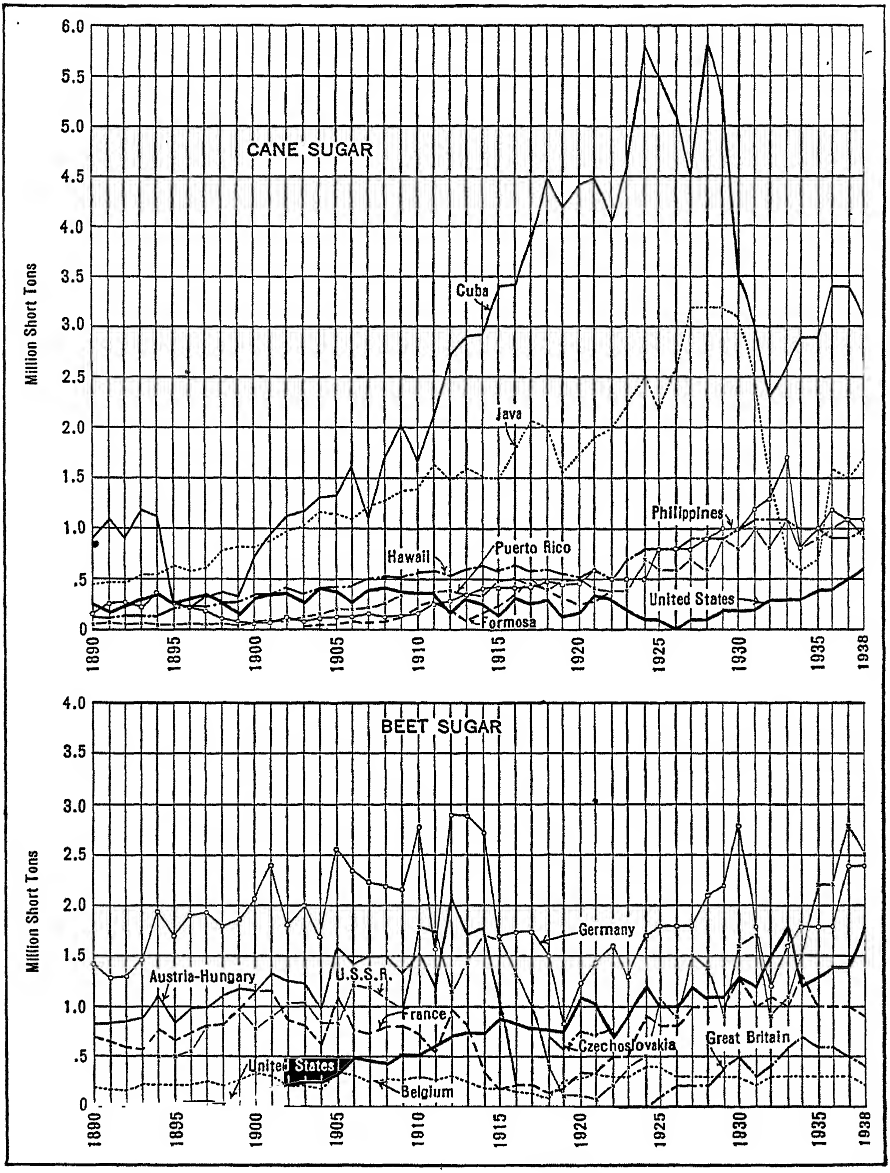
A convention was called at Brussels in 1901 and 1902, at which most of the European countries agreed to stop all export bounties whatever. As a result the world's sugar export went forward on a more normal basis, and the continent of Europe ceased to be important in the export sugar trade. The removal of export bounties lowered the price in exporting countries and raised it in importing countries. Thus England saved her colonies from the competition of sugar made cheap by export bounty, and the people of beet-growing countries had for the first time cheap sugar for home consumption. This made instant increase in consumption in beet-growing countries. In Germany it increased 50% in a year, and in France it nearly doubled.

Competition of Beet and Cane. The promise of nations to stop export bounties had nothing to do with tariffs and production for the home market, a fact that goes far to explain Figure 529.

Beet-sugar Growing in the United States. As a natural result of the labor and climate required, the sugar-beet industry was late in its establishment in the United States, although we have great land resources for it; and the graph shows what the tariff has caused us to do with it. The possible beet area of the United States is several times as large as the possible cane area, and seems to follow rather closely the July isotherm of 70° (Fig. 526). The sugar beet thus offers a money crop to the American farmer in those regions where the climate is a little too cool for the maximum development of corn. The beet with its heavy labor requirements did not interest the American farmer while corn land was still to be had for the taking. It had its practical beginning in the early nineties, 110,000 acres were grown in 1899, 470,000 acres in 1911, 651,000 acres in 1923, and 867,000 in 1939. The relative importance to some American localities is as great as in any part of Germany.

It is quite common in the beet-growing districts of the United States for the hand labor to be done on contract by newly arrived immigrants. The intensive character, large labor cost, mellow soil requirements and high yield of beet growing fit it especially to irrigated land. Irrigation also insures the dry October, a month in which warm rains can do so much injury to the beets. The adjustment of these factors makes the beet important in the Great Plains and Rocky Mountain area and California. Colorado, Nebraska (western), Wyoming, Montana, and Utah are important states. Colorado and California are the leaders. The adaptation of the beet to rather light soil makes it important in Michigan.

As already stated, the plant for extracting the sugar from beets costs two or three million dollars, and it requires hundreds of acres of beets to keep one running through the fall and winter season, and it must run for many years to be profitable to the owners. Hence it is to their interest to encourage beet growing and in America, as in Germany, the sugar manufacturer, through contracts with the farmer, controls the



These two graphs, showing the world production of cane sugar and beet sugar, carry the record of the bullet war, World War I, and the trade wars as effected by bounties and tariffs. Beginning with beet sugar we see the steady rise due to tariffs and bounties, the great slump due to World War I, with the fairly steady rise of the United States. In the cane sugar, two giants appear, Cuba and Java. They both fell before the blows of the depression of the 1930's. The story of Cuban compulsory restriction of production during the 1930's is one of the many interesting examples of attempted restriction of agricultural production to maintain price, of which there have been a surprisingly large number since they tried it with tobacco in the Jamestown settlement in the early days of Virginia.

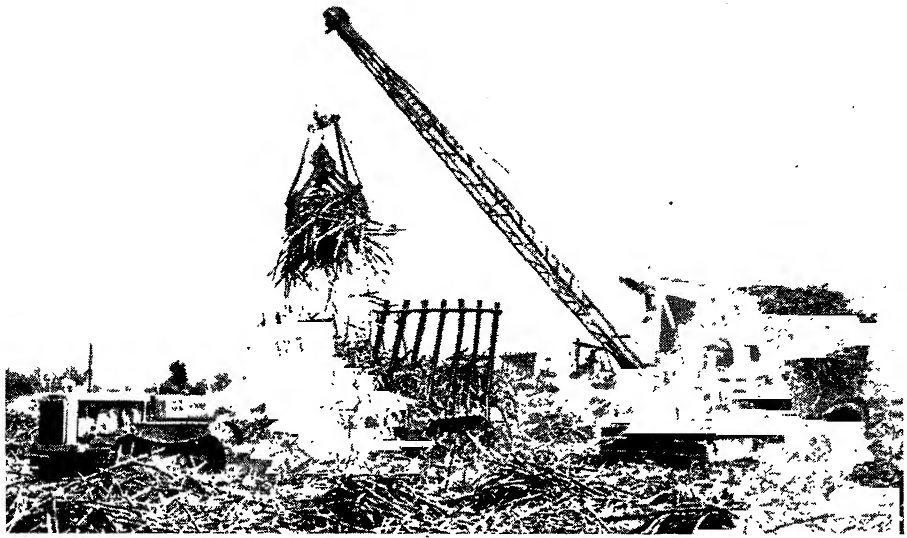
crop rotation, the method of beet growing and, to the community's benefit, becomes virtually a teacher of agriculture.

4. *Cane Sugar*

Climatic Requirements and Cultivation of Sugar Cane. The battle between cane and beet is carried on at long range, as the plants themselves never meet, but their identical sugars most assuredly do. The sugar cane is as distinctly limited to warm climates as beet is to cool ones. It will grow on the edges of the temperate zones in such districts as Louisiana, Natal, New Zealand, and Cape Colony, and has been grown at 32° north latitude in Spain and 31° south in New Zealand, but it is at home and does its best only where free from frost. It invades the frost zone only where there is a long growing season and when freedom from competition is provided by means of tariffs and bounties. The best cane sugar crops require such conditions as exist in Cuba, Java, Brazil, and India, where there is a temperature of 75° or 80° F. the year round and a rainfall of 60 inches or its equivalent by irrigation. The necessity of much sunshine gives irrigation a great advantage. Cane planting consists in putting cuttings in the ground, or, as in Louisiana and Cuba, in laying in the bottom of a furrow a row of cane stalks which sprout up from every joint. After eight months' or more growth and cultivation the leaves are stripped off, and the stalks are cut, usually by hand, and carried away to the factory. The transport of the cane to the sugar mill is a serious problem. A good crop is 15 or 20 tons per acre. The fields are often muddy and the distance to the mill is increasing with the size of the mill, which is large. In backward countries, cane is sometimes carried on mule back, but in the great shipping districts, carts drawn by oxen or mules are used, while the best-equipped sugar plantations recently had portable railway tracks placed in the fields and diminutive plantation locomotives to pull the cane cars.

A new technician has appeared in

This picture of sugar cane shows that if the cane cutter is successful, it will relieve poor human beings of a heavy, hot and sweaty job.



This cane loader, working somewhat steam shovel-wise, picks up as much as 700 pounds of cane, drops it on the car from which it will again be lifted into the factory for the next process.

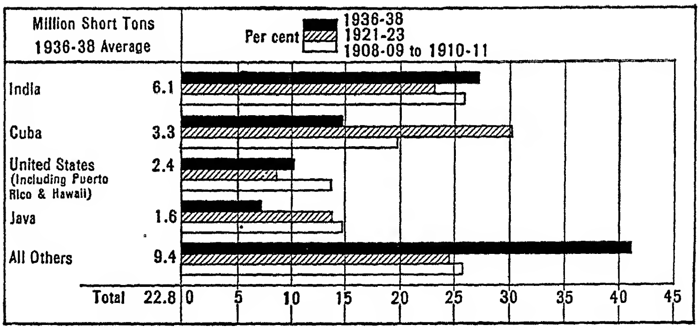
the form of "bulldozer" harvesting. The tractor-powered bulldozer drives a blade through the soil about four inches below the base of the cane stalks, which are lifted up and dumped into piles. A crane equipped with a grab then removes the cane from the piles to the trucks. There has been an expansion of the use of trucks for taking the cane to the mill. The portable tracks and puffing locomotives formerly conspicuous in Hawaiian fields have largely disappeared, along with the flumes by which some of the cane was floated to the mills. The Hawaiian cane fields therefore give us the next exhibit of the Machine Age in sugar agriculture.

Mechanical cane harvesters of various types are also used in Louisiana (272 used in 1943).[6]

Cane resembles beet-sugar making in the size of the plant required economically to extract the juice, get out the sugar and dispose of the by-products. Several thousand acres of cane make a good unit. It is difficult to guarantee this amount of cane year after year, if many independent tropic farmers must be depended upon. This tends to make the sugar company grow its own cane—a process that is much easier than the growing of beets by a corporation on a huge scale. Cane growing is a far less scientific agriculture than is beet growing. Many plantations in Cuba and even in the United States are still growing the crop year after year on the same ground without adequate crop rotation. As this cannot continue indefinitely, the establishment of crop rotation will require a considerably larger area and thus increase the difficulty of carrying cane to the mills.

A sugar-cane plantation, with its cen-

[6] *Sugar Reference Book and Directory*, v. 13, p. 4.



World production of cane sugar, three-year averages, three periods, actual production for the last period. The great difference here between India, Cuba and Java is the difference between those who eat their sugar and those who try to sell it in a world where markets are all depressed and buying power cannot keep up with appetite.

tral (mill), transport and workers, is a big business enterprise—almost a factory town with a big agricultural village thrown in.[7] With this big mill, it is now possible to turn all sugar-cane by-products into useful substances. The cane tops can be used for cattle feed; the dry trash (it contains 40% of pure cellulose) can be made into pasteboard and wrapping paper. The bagasse (cane after crushing) can be made into wall board, or destructively distilled to produce charcoal (52.5%), acetic acid, and tar. If burned as fuel, bagasse leaves an ash that can be used as fertilizer, or to make glass. Recent research has shown that molasses can be used as a base for butyl and other fermentations, as well as a common alcohol. In short, nothing need be wasted.

It is one thing to have possibilities, and another to use them. It has been said that the failure to introduce modern production methods into Cuba causes a production loss of 25% of sugar in the bag.

The Distribution of Cane Growing. The adaptation of the sugar cane to practically all moist lowlands lying between Louisiana and Argentina in the New World and between southern Italy and India, Natal and Queensland in the Old World, gives an easy source of sugar to all tropic peoples. Instead of candy the half-naked child sucks a section of cane in many a tropic village. Although cane growing is a local industry in practically all damp tropic countries, only a few of them export it, because, while a crude ox-driven mill will suffice to crush the cane for local use, and it can be boiled in an open pot, it cannot compete in the world market. In India, for example, it is estimated that there is an annual production of over 6.1 million tons, exceeding Cuba, but it does not enter into foreign commerce because all this and more is consumed locally.

Sugar cane is grown in the lowlands of Mexico and of each of the Central American countries, and also in every

[7] See J. Russell Smith and M. Ogden Phillips, *North America*, Harcourt, Brace and Co., New York, 1942, pp. 835-38.

South American country except Chile. But throughout most of this region the process of manufacture is crude, the conditions of transportation, of labor, and of capital, and often of land, are unsuitable for the development of a large cane-sugar export, although there are in tropic America large areas of excellent cane land. This is especially true on the shores where the trade wind blows. The lowlands of the Caribbean coast of Mexico and Central America are excellent examples of such lands.

The main export supply of sugar comes from especially rich plains and favored tropical shores, such as Cuba (limestone plains) and Java (new volcanic ash), with secondary sources of supply in Hawaii (also volcanic), the Philippines, and Puerto Rico. At no place is cane sugar grown for export in locations distant from the seashore and from ocean transportation.

Sugar Export from the Mainland of North and South America. The mainland of Tropic America is strangely devoid of sugar export. Some is exported from the irrigated valleys of the Peruvian Desert, some from the British colony of Guiana on the northeast coast of South America. British Guiana is among the most interesting of cane-sugar producers, showing intensive cultivation and the untouched wilderness side by side. Large areas of coast swamp have been reclaimed in the same way the Dutch (the original settlers of Guiana) have done in Holland. This is the more unusual because most of the country remains a great forest absolutely uninhabited, save for a few uncounted natives living the primitive life. The explanation of this unused land is to be found in the climate, which is so ill suited to white colonists that they are but a small per cent of the total population and merely occupy positions under the government and in the management of stores and plantations. In the attempt to people this fertile desert and work the productive lands, the government has permitted the importation of East Indian coolies who now comprise nearly half of the one-third of a million population. These immigrants were accustomed to growing rice and sugar cane. This has led to the rapid increase of rice growing along with the continuance of sugar-cane growing which has been for many years the main export product of this colony. The reclaimed swamp land is very fertile, has a large rainfall, and, in addition, the flat and level dyke lands are easily irrigated for both sugar and rice. Further than that the drainage ditches serve as canals for the boats that carry cane from field to factory.

The growing of sugar cane, which began in Brazil as early as the seventeenth century, held for many years the economic position in that country now held by coffee. Based on slave labor, it fell into a decline with the abolition of slavery, and until very recent years had made no appreciable progress. Most of the sugar was consumed locally, although the central coast regions usually had a small export. Because of the war, Brazil expected to break her sugar record in 1945.

Argentina has an isolated cane-sugar region in the subtropical province of Tucuman, latitude 28° south. The production per acre is rather low, but the total production is sufficient for the national supply, and at times even provides a small export.

Sugar in the West Indies. The history and description of sugar growing in the West Indian Islands is in itself an economic and geographic study of some magnitude with many instructive politico-economic phases. In the sixteenth and seventeenth centuries,[8] these islands were much prized by the colony-owning powers of Europe, and were the center of the world's sugar production. At the end of the eighteenth century they were in a high degree of prosperity, based on plantations owned by Europeans, worked by African slaves (who died like flies), and largely given over to the growth of export sugar and rum, distilled, then as now, from the cane juice.

The emancipation of the slaves brought decline in the sugar production of the West Indies, as in Haiti where political chaos succeeded French rule and the jungle crowded more and more into the abandoned cane fields. In addition, the cane growers faced the severe and growing competition of European beet sugar, which still further depressed the prosperity of the island plantations. While sugar continued to be an export from islands such as Trinidad, Jamaica and Barbados, the industry failed to advance, retaining until very recently all the old primitive colonial methods. The discontent of British West Indian colonies, some of which desired to become possessions of the United States to get advantage of free import of their sugar into the United States, was one of the reasons leading up to the British action that produced the Brussels sugar conference of 1903.

The advantage of free admission of sugar into the United States is well shown in Puerto Rico. After its annexation, twenty-five years of free admission of sugar into the United States increased the crop of an island less than half as large as New Jersey from 50,000 to 400,000 tons in 1919, and 1,080,000 in 1942. The sugar is grown on the coast lowlands, the windward northeastern side having sufficient rainfall for the crop in most places, but the drier southwestern side is forced to use irrigation. Practically all the suitable cane-growing land has been planted for 20 years. Production costs for sugar are considerably higher in Puerto Rico than in Cuba, because of the necessity for using fertilizer and the greater expense of cultivation. The success of sugar planting in Puerto Rico has come about largely through the consolidation of many small plantations and the modernizing of factories by American capital and management.

The same process of capitalistic consolidation is in progress more slowly throughout many of the West Indian islands. The Dominican Republic, to which Columbus brought sugar cane over four hundred years ago, has some huge plantations under American management and a growing export of sugar. Large areas of level untilled cane land, underlaid by coral limestone which weathers into a soil of great fertility, give promise of future possible expansion for the sugar industry. The British West Indian planters are likewise attempting to apply modern methods to this, one of their earliest colonial indus-

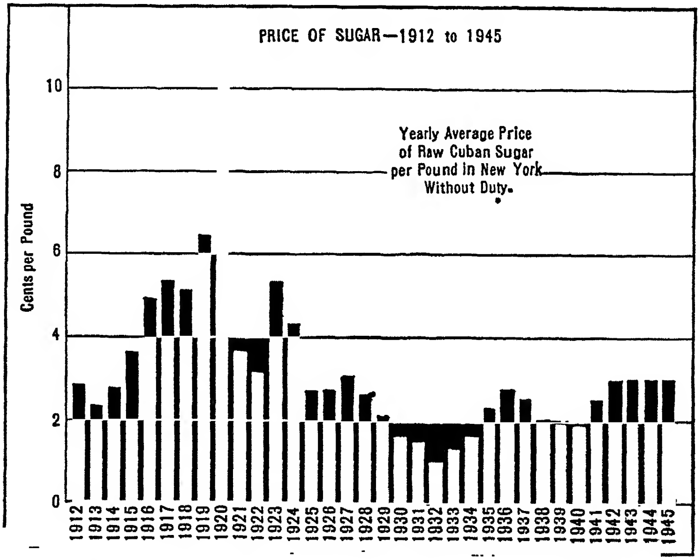
[8] For graphic evidence of the high esteem in which a sugar colony was held, see Vilhjalmur Stefansson, *Northward Course of Empire*, Harcourt, Brace & Co., New York, 1922. Benjamin Franklin reported that he had a tough job in persuading the British in 1763 not to give all Canada to France in exchange for Guadeloupe (sugar and rum).

tries, which yields substantial export from Jamaica, Barbados, and Trinidad.

Cuba. There is a strong contrast between the small-scale semi-Oriental industry of Haiti and some smaller West Indian islands and the scientific and large-scale operations of both Cuba and Hawaii. Cuba is the second largest producer in the world, yielding at times one-fourth of the total product, and leading all others in the amount exported. In 1940, the export of sugar and molasses was $94,000,000; tobacco, $12,000,000; food, $7,000,000. Production went up like a rocket after stabilization of government under the influence of the United States made capitalists feel safe in making the large investments required by cane sugar. Another weighty factor has been some tariff preference (changed from time to time) for American imports of Cuban sugar, most of which naturally comes to this country.

Cuban sugar plantations are usually of large extent, most of them owned by Europeans or Americans, mostly Americans. Hundreds of millions of American dollars are there. One company has offices that occupy a whole floor of a large New York office building. This helps to explain Cuba's excess of exports over imports.

Cuba has been able to produce such great quantities of sugar because she has had a fairly stable government, a popu-



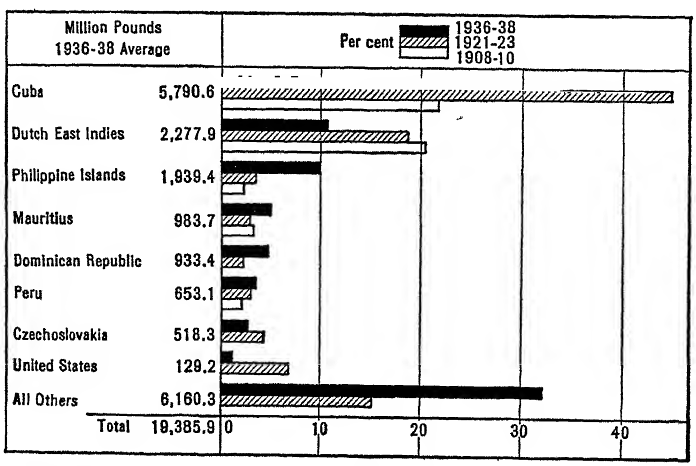
If this had been made by months, the fluctuations would have been much greater. The low prices of 1931-32 produced the forcible restriction of production by the Cuban government. The flat price of four years of World War II shows again the hand of government. The wild prices of 1919 and 1920 had the usual result of such a spurt. People acted as though it would last forever with the result that by 1922 the Trade Wind was whistling through a row of unfinished palaces that stretched along the best residence shore near Havana. Sugar millionaires of 1920 started them, but before they could be finished, the bubble had burst, and the palaces stood in unfinished ruin. (Data from *Weekly Statistical Sugar Trade Journal.*)

lation superior to that of most tropic countries, and an abundance of good, smooth, rich, well-drained limestone land. Only one-twelfth of the island is in cane fields, so the planters exploit land as we do in the United States. When land became exhausted the industry has been able to move, generally to the eastward from Havana where the industry had its first center. The increasing labor scarcity was a limiting factor before the over-production of sugar of the 1930's.

During and immediately after the war, when the price of sugar was high (see Fig. 535), Cuban sugar planters made huge fortunes but in normal times the low price at the plantation leaves only a moderate profit. After the crash in prices, the trade wind whistled through the ruins of a row of unfinished sugar-king palaces along the shore near Havana.

Hawaii. The Hawaiian Islands, with a total area nearly as great as Massachusetts, are second only to Cuba as a source of sugar import for the American market. The sugar yield per acre is the largest in the world, due first to the virgin fertility of the phenomenal soil, decayed lava from the great Hawaiian volcanoes. Fine yields are further guaranteed by commercial fertilizer, skillfully applied, and by irrigation on the leeward side of the islands. In the absence of suitable rivers at the right elevation for stream diversion, tunnels have been dug to carry water from windward to leeward side of the island of Oahu. Water is also gathered near the sea level from streams and wells and pumped up, sometimes hundreds of feet, through iron pipes and spread over the fertile lava slopes, making some of the most spectacular plantations in the world. All this effort can be afforded because of free entrance into the American protective tariff market. But the yields!—7-8 tons to the acre, compared to Puerto Rico's 3+; Philippines' 2; Florida's 3+; Louisiana's 2.

This special privilege to the sugar



The world's export of sugar, three-year averages by percentages, three periods, one period by quantity. Cuba restricted. The Philippine Islands had a tariff preference in the American market. Dominican Republic and Peru played lone hands and would not (could not) stop growing sugar.

growers of Hawaii has caused intensive and careful cultivation[9] and has led to high profits and the suppression of other industries in the islands. These profits began when the islands had a few thrifty white people and many easy-going natives, giving an admirable opportunity for the formation of great estates which loudly called for workers. These came from China until the Chinese exclusion treaty shut them out in 1898. Then came Japanese until the Japanese Government checked their emigration to the islands. Then came laborers from the Philippines, Puerto Rico, Portugal, and Russia.

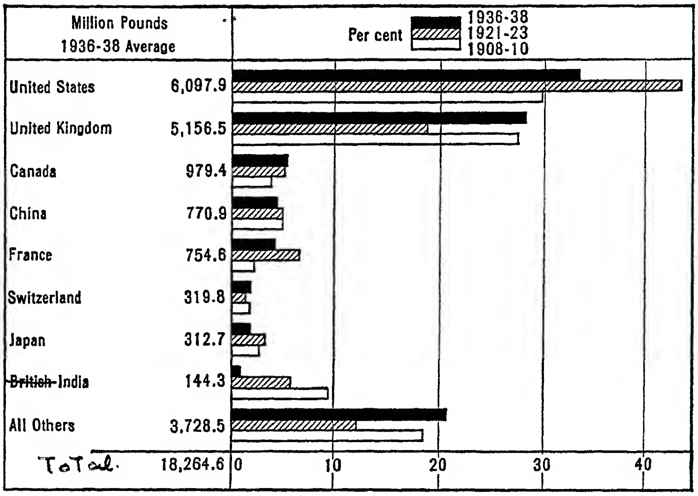
As an accompaniment and cause of this population condition the sugar is grown on a few vast estates and controlled by a few large companies. Cane production in Hawaii has about reached its economic limit because most of the suitable land has been planted.

The Advanced Development in Javanese Sugar Growing. Java, an island about the size of New York, is very remarkable in the world's commercial geography. Forty per cent of the land is cultivated. It supports a population of 35 million (817 per sq. mile) who yet have food products for export. The chief export is a million tons or more of cane sugar, of which it furnished about one-sixth of the world's commercial crop, being second only to Cuba. In sparsely peopled countries like Cuba, sugar can often be grown on newly cleared land, and as the cane will live for many years with an annual cutting, new sugar lands are often made to give six or eight or ten crops before replanting. In Java, the larger area under cultivation makes it impossible to keep moving to new land, hence a more scientific agriculture than is to be found in most cane-growing regions.

Since the first cutting of cane, following the plowing and planting, is always the best, a field is allowed to yield but one crop, as is the case in Louisiana because of frost. This is followed the next year by beans, then by corn, then rice, then back to sugar. Under this systematic cultivation and a complex system of government control which at times amounts to compulsory labor, the sugar has increased manyfold in the last sixty years. The natural export market for Java sugar is the Far East—Japan, China, and India. In addition a large part of her export goes to the United Kingdom, which is, next to the United States, the greatest sugar-importing country in the world.

The Philippine Islands. These islands have admirable soil, temperature and rainfall for the growth of sugar cane, which is third in importance among the island crops. Records show that Philippine sugar was imported by the United States as early as 1795, but under Spanish rule the industry failed to expand. It did so, however, as soon as the Americans began to rule the islands. The Philippine crop is about equal to the Javanese export. The sugar resources are much greater than those of Java, which is but a third as large; but the population is 16 million rather than 35, there is no Dutch Government with a

[9] "Nowhere else is there so effective an application of highly specialized machinery to agriculture, such extensive use of commercial fertilizers, such a comprehensive system of irrigation, such attention given to discovering and applying of the principles of scientific agriculture."—The United States Tariff Commission.



World sugar import, three-year averages by percentages for three periods, one period by quantity. Note the inadequacy of the United States crop with regard to United States consumption. Rising home production combined with hard times caused us to import a smaller share in the 1930's than in the 1920's, but sugar is still one of our greatest imports.

system of compulsory labor, the industrious Chinese are excluded, and the high price of hemp and copra give other outlets for enterprise.

The natural market for Philippine sugar seems to lie in the Far East, rather than in the United States which has Hawaii and Puerto Rico much nearer, and Cuba with her vast sugar supplies as a next door neighbor.

Africa and Her Islands. There is good sugar land in Egypt and in many an African colony; but it is only in the moist corner (Natal) of the Union of South Africa that an insignificant export (less than 100,000 tons) arises.

Sugar is the predominating export from the two tropic islands of Mauritius (British, 720 square miles) and Reunion (French, 970 square miles) in the Indian Ocean near Madagascar. They have a combined population of over half a million, of whom a large part are industrious coolies brought from India and China, so that these small lands play a comparatively large role in sugar commerce, exporting nearly all of their quarter of a million ton crop.

5. *The Supply and Production of Sugar in the United States*

The United States, consuming 7 million or more tons of sugar, has been growing cane sugar for a century, beet sugar since 1890, yet our import increases year after year, in spite of the fact that our home product has trebled within thirty years. During the years 1918-22, Cuba supplied 50% of our sugar, Hawaii 11.4%, Puerto Rico 8.2%, Philippine Islands 2.7%, and imports from other countries 5%, while our domestic beet 18% and domestic cane 4.7% amounted to 22.7% or about 1,200,000 tons, scarcely one-fourth of the total

amount consumed.[10] The average annual rate of increase in our sugar consumption during the past century has been about 5%, and the United States now is the greatest sugar-consuming country in the world, with an average of over two pounds per week per person.

Cane Sugar in the United States. The home-grown cane-sugar supply shows small prospect of supplying the home demand. In 1909-11, the crop was 342,000 tons; 1930-32, 192,000 tons; and 1937-39, 443,000 tons. The areas suitable for cane growing are limited, and inferior to tropic districts. The superiority of the tropics is in climate rather than soil. The freezing of the American winter makes it necessary to plant the cane each year in Louisiana and then it often interferes with the crop. In the frost-free climates there are records of fifty yearly cuttings from one planting, and in parts of Puerto Rico it has lived and been cut for twenty years, while the Cuban plantations regularly cut eight or ten crops from one planting. Those of Louisiana must plant annually four tons to the acre, while the average yield is 14 to 16 tons per acre. There is the further handicap in the expensive labor of planting, occasional frost injury, and the fact that Cuban cane yields more heavily and has one-fourth to one-third more sugar in it per ton than that of Louisiana. These factors combine to make it plain that our cane-sugar industry is one which, like our beet-sugar industry, could not survive without the high price produced by a protective tariff.

Owing to these climatic limitations cane-sugar production, even with tariff aid, only attains importance in the southern third of Louisiana, a coast strip in eastern Texas, and a few locations in Florida.[11] The sugar territory of southern Louisiana is part of the swampy flood plain of the Mississippi River. The only tillable land is within a mile or two of the Mississippi, or other streams, where the deposits of the overflowing streams have built up a little land a few feet above the general swamp level. The total cane-sugar crop of the United States is not increasing much, and only amounts to about 6 pounds per capita for our people.

The limitation is not set by land possibilities, for it is reported that we have 10 million acres of good cane land and now cultivate one-fortieth of it. It should be kept in mind that this same land, where drained, may be good for rice, cotton, corn, and many forage plants and meat production. The American cane-sugar growers have always had to combat labor scarcity as well as troubles of climate, and above all the uncertainties of the tariff. Also, they compete with a huge beet-sugar industry.

The extraction of cane molasses for local use is a simple process rather widely distributed in the South, and a little cane is grown for this purpose as far north as Arkansas and eastern North Carolina.

[10] Compare these figures with those of 1939, page 527, this chapter.

[11] Experimental successes in the newly drained Everglades (requiring fertilizer) suggest a new sugar region in a climate with much less freezing than comes to Louisiana. The production, 1930-32, 30,000 tons; 1937-39, 71,000 tons, is as yet insignificant. In recent years, large areas of peaty everglade soil have been ruined by burning, because the water table had been lowered by foolish drainage without plan.

6. *The Future and the By-products*

The growing of any large amounts of sugar outside the tropics has only succeeded where governments have shielded the industry from the competition of the tropic cane, and if the time should come when the pressure of temperate-zone population upon land resources makes us need our sugar lands for other crops, an indefinite amount of tropic land is ready to grow sugar for our supply. There appears to be much improvement possible in cane-sugar production in suitable localities, but the recent mechanization of beet-sugar growing suggests an interesting race, in which a vital factor is the low tropic wage level.

Cane Sugar as a Local Supply Crop. Beet sugar is only edible after it has been through the machinery of a great refinery, after which it is not unlike that of cane. In contrast to this, cane juice is a prized article of food in all stages of manufacture, and is often sucked directly from the cane itself, which is nature's stick of candy for the tropics, where it is widely used in that simple way. Living and yielding for years beside the native's thatched hut, the cane patch is a pleasing element in that completeness of support for the simple life which the tropical climate yields to man with so little labor on his part. Crushed by ox or manpower between rude rollers and boiled in the family kettle, it makes a cheaper sugar supply than the grocery store yields in the land of frost.

The cane is an important and widely distributed source of food throughout the thousands of Polynesian islands from Australia to Singapore, and thence to Hawaii, and the scattered isles to the southeast. It becomes an industry where the human element is strong, as in Java. In the Fiji Islands there is an important cane-sugar industry, producing under British management about one-third as much as the cane-sugar crop of the United States. The chief market for this sugar is in the neighboring islands of New Zealand. In the warmer part of Australia there is a large area of admirable cane land, but the rainfall is less regular than in some other lands. Considerable sugar is produced in Queensland and a lesser amount in New South Wales. But the Australian population is less than two per square mile, and the strenuous desire of the Commonwealth to remain a white man's land has caused the enactment of laws prohibiting the admission of the colored laborers (Hindoo, Chinese, or South Sea Islanders) who had been the planter's dependence. As white laborers will rarely go to the tropics, the Australian sugar industry is under a serious handicap. It is nevertheless increasing, and the export of 180,000 tons, 1925-29, reached half-a-million tons in 1938. Then the war—

The By-products of Sugar Making. There is a great difference between the sugar mill that suffices for making the sugar and molasses for local use in the interior of Venezuela, Guatemala, or Puerto Rico and the modern mill for making export sugar. The local mill may have two or three small rollers turned by oxen, getting 50% or at most 75% of the juice. This is boiled in open vats, a primitive method which leaves much of the sugar in the form of molasses, but the molasses is one of five great staples in the nourishment of the masses in tropic America. The others are corn cakes, bananas, cassava, sweet potatoes, and beans. In great commercial

sugar plants, however, enormous rollers with a pressure of many tons are driven by steam, 90% of the juice is extracted, and a washing of the crushed cane gets an additional 5%. The juice is evaporated in vacuum pans, which save more sugar and require much less skill, because the evaporation takes place in the vacuum at so much lower temperature that there is less danger of burning. The molasses that comes from this more scientific process has so little sugar left that it is not fit for human food or even for the distillation of rum, which has for centuries been the great by-product of the sugar plantations of the West Indies. But rum, like good molasses, is now a by-product only of a cast-off process used in the less efficient plants of small plantations or backward sugar regions.

The tasteless molasses of the modern plant is fit only for the distillation of industrial alcohol and the preparation of cattle feeds. When it is considered that a small fraction of the possible sugar area of Cuba is in use, we see here the possibility of an important trade with the live-stock producing countries of the temperate zone for, owing to the rising price of cattle foods, wheat bran and corn are now nearly as expensive as cane sugar, which is as nutritious and as acceptable to the ruminants as to man. Ten pounds of mill (black-strap) molasses are, with the addition of 2 pounds of cotton-seed meal, almost the exact equivalent as stock food for 10 pounds of corn.

There is no natural reason why we might not in the near future have a very important commerce in sugar and sugar by-products from the tropical countries, which will help to make cheaper meat, milk, and wool in the temperate-zone countries.

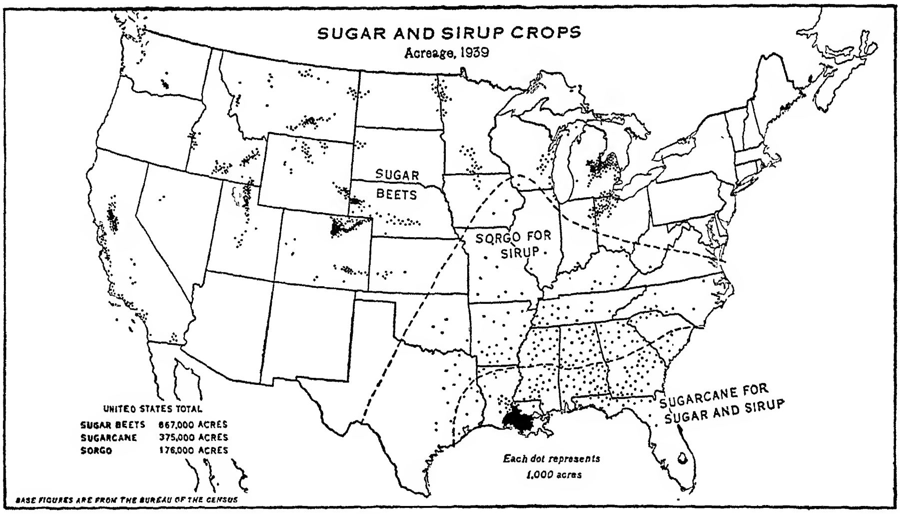
Crushed cane, from which the sap has been extracted, called bagasse, is chiefly used for fuel in the boilers that run the engine of the sugar mill. A recent improvement permits it to pass directly from the crusher to the furnace, avoiding much labor in spreading it out to dry in the sun, as has been done for a century. Its suitability for paper making is now giving it a new use in a few places.

Maple Sugar. Maple sugar is produced by the evaporation of the sweet sap of several varieties of maple which will grow over large areas of eastern and northern United States, where it was a very important factor in the days before world commerce in sugar. The sap only flows in quantities sufficient for satisfactory sugar making where the days are bright and sunny and the nights are cold. This climatic factor limits sugar orchards to the region from Indiana east and north. It is particularly important in New York, the mountain region of Vermont and New Hampshire, and the adjacent parts of Canada.

The sugar maple tree that yields from the time it is twenty or twenty-five years old till it is seventy-five or a hundred certainly has all other sugar producers distanced for permanence, but the yield is at present low—its sap .05-(rarely) 7% sugar—giving 1-7 pounds of sugar per tree.

We got the industry from the Indian, and have done nothing to improve the tree.[12] It is anybody's guess as to what would happen if it should receive the genetic attention that has been bestowed on the sugar beet.

[12] See J. Russell Smith, *Tree Crops,* Harcourt, Brace & Co., New York, 1929.



The growth of small quantities of sorghum in Iowa and Minnesota, taken in combination with the temperature map for beet sugar, further back in this chapter, shows that we can grow sugar of some sort over much of the United States. If the Indian had grown sugar-bearing sorghum as widely as he grew tobacco and corn, the Colonial history of the Americas might have been different because of the lesser charm of the western cane-sugar plantation as a factor in European foreign policy. But we had to wait a couple of centuries to get sorghum from the dark-skinned men of Asia and Africa.

Sugar from Sorghum. Another sugar plant, sorghum, a member of the corn family, an annual resembling both kafir corn and broom corn, has long been grown in southern, central, and southwestern United States for the manufacture of syrup for local use. The juice is extracted and treated in the same way as the juice of the sugar cane.

During the Civil War when the blockade between North and South stopped shipments of sugar and especially molasses from Louisiana to the North, sorghum was quite generally grown throughout the corn-growing parts of the North, and in the form of syrup used as a substitute for the product of the sugar cane. A century ago this plant exceeded beets in the sugar content of its juice, but progress in improving it has been slow. Experiments carried on for many years at Fort Scott, Kansas, have at last resulted in the making of satisfactory sugar from it. Now that the laws of plant breeding are better known, its sugar content may be susceptible of as great improvement as has taken place in the beet. It is possible that a century hence it might rival, or even displace, beets in the United States, because like corn it can be cultivated with work animals and machines and lends itself to the really extensive mechanized agriculture.[13] If the people of the United States should ever happen to have permanency as an element of national policy, they will try to import the products of row crops whenever feasible and save our own soil from the ruin by erosion that accompanies row crops that are not grown on the level.

[13] *Facts about Sugar*, vol. 31, Oct., 1940, p. 42.

. . . 18

Condiments and Tobacco

Modern man has not discovered any important new plants carrying stimulants that satisfy large numbers of people. The primitives found them all—long ago.

Caffeine or theine is found in five plants, as follows:

Coffee beans	0.8–1.7%
Cacao beans	0.1–0.8%
Kola nuts	1.0–2.0%
Tea leaves	2.0–5.0%
Guarana (the roasted fruit of Paullinia—S. American)	2.5–5.0%

Western peoples have gladly adopted coffee, tea and cacao.[1]

1. Coffee

Distribution of Coffee. Coffee is grown in many countries and has become a regular article of consumption in many parts of the world. Several factors combine to restrict coffee-producing to limited but widely scattered areas. The plant cannot endure any frost and is therefore limited, with a few insignificant exceptions, to the region within the tropics. The greatest coffee region, that of Brazil, is close to the edge of the temperate zone, and some coffee is produced as far out as 28° N. and 38° S. Latitude. The plant requires a hot climate, yet in many coffee regions the full blast of the sun is too hot for it, particularly for the young plants, and high shade trees are scattered over many plantations to cast some shade, while the young trees are grown with corn, bananas, beans or coarse varieties of peas to protect them from the full rays of the sun and also to get a side crop. The climate must be moist as well as hot, with a rainfall from 75 to 120 inches, yet the soil must be rich and also well drained, which practically limits coffee growing to hills and highlands where the streams have rapid fall to give the necessary drainage. These conditions, therefore, tend to locate the best coffee-producing districts upon plateaus and hilly regions. In some Andean locations it is grown as high up as 6,000 feet, and the quality changes with every thousand feet. As the coffee is usually grown for export, it must, in addition, be reasonably near the seacoast, and a considerable population is necessary to perform the large amount of labor required in caring for the crop.

[1] Per capita consumption of coffee per year (average for 1934-38 in pounds):

Sweden	17.0
Denmark	16.5
Norway	13.7
United States	13.7
(U. S., 1944, about	18.0)
Belgium	13.0
Finland	12.1
France	9.7
Netherlands	9.3
Switzerland	8.4
Germany	5.5
United Kingdom	0.7

A slight drop is expected in U. S. consumption after the war.

Source: Coffee, a Summary Statement, Third Inter-American Conference of Agriculture, Caracas, July 24, 1945.

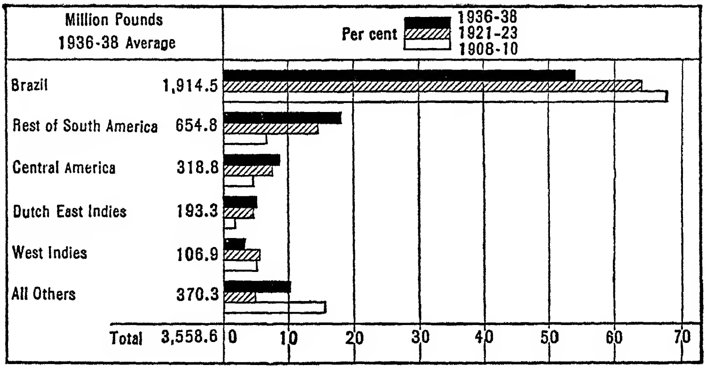
History of the Industry. Coffee, unlike wheat, corn, rice, and beans, is not a staple handed down from distant ages. The plant is probably a native of Abyssinia, whence it was taken to Arabia about the eleventh century. Its spread was slow and it was only in 1562 that the first coffee houses were opened in London. As an important article of commerce, coffee really belongs to the nineteenth century, the quantity consumed having practically doubled between 1855 and 1885 and again by 1912. It is still increasing. American consumption went up 20% between 1943 and 1945. The source of chief commercial supply has shifted much. At first, it was the product of Arabia, then the West Indies, then Java had the supremacy, and lastly Brazil has taken the lead with a production far distancing all competitors.

The Growth and Preparation of Coffee. The tree naturally grows to from 25 to 30 feet in height, but in the coffee orchard it is frequently pruned and kept down to from 5 to 12 feet in height to permit easy picking of the berries. The berry, which looks much like a cherry, usually encloses two coffee grains in its pulp. After picking, the berry is put through a number of mechanical processes the first of which takes off the outer pulp. After this, the berry is dried in the sun, a process requiring from six to eight days. Other machines then remove the two layers of inner husk, and various sortings and gradings separate the grains so that those comprising each kind of coffee are of the same appearance and size. Rather complicated machinery has been invented to do most of the coffee curing after it has once been picked by hand. This machinery is made in Europe and the United States.

Arabian Coffee Growing. One of the best places for the growth of coffee is found on the slopes which face the lower plain along the Red Sea in Yemen, the southern part of the Arabian peninsula, and the home of Mocha coffee. Here the shade-loving coffee tree has the advantage of a mist which arises on the lower plain almost every morning in the year and toward noon envelops the coffee-planted slopes in a haze which keeps off the full rays of the sun and also gives the proper moisture for the good development of the plant and the production of its seeds.

The fine quality of this Arabian coffee is due chiefly to the fact that it is carefully prepared, most of the crop being bought on the trees by Turkish and Egyptian merchants who personally superintend the harvest. In Yemen coffee is purely a money crop, and is not used by the natives, who drink a decoction of the dried hulls. Mocha coffee stands high in reputation. The output is small, 1½% that of Brazil; but it has increased a little in recent decades. Aden is the port of shipment, not only for the Mocha coffee of Yemen which reaches the coast by caravan, but for large quantities of Abyssinian coffee, some of which is still picked from wild trees. The coffee export of Aden in 1939 amounted to 87,000 sacks (132 lbs. each). The United States got about a fifth of it. Most of it goes to Europe, but the Middle East is buying more and more of it.

India and Ceylon and Dutch East Indies. The British Government, which has done so much to stimulate agriculture in its colonies, encouraged the es-



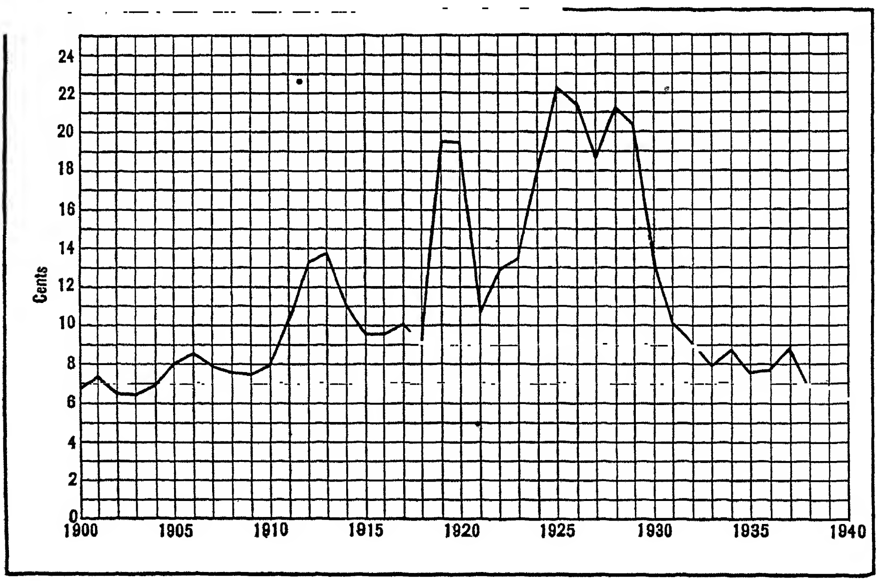
This graph of the world's coffee export for three three-year periods by percentage and by quantity for the last period, shows the results of Brazil's attempt to control prices by limiting exports. The little fellows stepped up their production.

tablishment of the coffee industry in India and Ceylon. An experiment station at Peredeniaja, Ceylon, is testing new varieties and making hybrids based on vigorous stock from the wilds of the Congo. The chief Indian district is located on the eastern or interior slopes of the Western Ghats Mountains in southern India, where elevation and climate suit it. In Ceylon, with its moist highlands, coffee growing quickly assumed an important place, and by 1880 was the chief export of the island, $15,000,000 worth being sold abroad annually. But a fungous disease producing leaf rust broke out in Ceylonese coffee plantations, so injuring the trees that they could not produce much fruit, or killing them outright, bringing ruin to many coffee planters. Some sought substitutes in growing cinchona, but most turned to tea, which has almost replaced coffee as a crop upon the Ceylonese highlands. The only way to circumvent the blight which killed coffee of the Arabian species was to introduce the more hardy Liberian coffee, a native of west Africa, and even that is not entirely immune to the blight. New varieties of coffee are now grown in Java, a name under which not only the product of this island is sold, but also the small amount of coffee produced in Sumatra, Borneo, and Celebes and some from other places. The Java coffee has a good quality because it is grown at an elevation of from two to four thousand feet. For a time it was grown on government plantations, where careful measures in harvesting the crop were rigidly enforced. In recent years this educational process has been discontinued, and the natives are growing much of the crop, which amounts to less than one-tenth that of Brazil. In 1934-38 the average annual shipments of coffee from the Dutch East Indies amounted to 188,000,000 pounds, or 5% of the world's total coffee exports.

Coffee in Tropical America. Coffee is one of the best money crops for the tropic highland, and for this reason is well suited to Mexico, Central America, and western South America. In all these regions the ruggedness of the country makes transportation difficult, the roads

are exceedingly bad, and the trail for pack animals is often the only means of access. Only valuable products can pay for such transportation, and coffee, worth from 5 to 25 cents a pound, stands in a class alone when compared with wheat worth about two cents a pound, or lumber with its low value and difficult form, or coal, sold at 2 or 3 pounds for a cent. Geographic and economic factors combine in an interesting way to influence coffee production in mountain districts. The elevation that produces the best coffee conditions of moisture, temperature and slope also makes a more endurable climate that has attracted the bulk of the population of nearly all tropical American countries. Into this natural labor situation, coffee fits well with its actual and relative ease of transportation. The high prices prevailing in 1887-96 made coffee growers very prosperous. It became one of the chief money crops in Mexico, Central America, Colombia, Venezuela, and Brazil, and plantations were started in several East African colonies and a few other places.

Mexico and Central America. In Mexico coffee does best in the middle one of the three topographic zones which comprise that varied country. The first division, the hot low plains along the seacoast, are considered too hot for coffee; the second, the high plateau enclosed between the eastern and western cordilleras, is too dry and too cool, but the outer slopes of the plateau, the so-called warm land of the Mexicans, with its good rainfall and its succession of fertile, warm valleys and forest-clad slopes, is a natural coffee zone. Some of the plantations extend south as far as the Isthmus of Tehuante-



Average price by years of the United States import of coffee per pound. Consider the changed psychology that must result from receiving the price of 1925-30 after receiving the price of 1905-10 and receiving the price of 1940 after receiving the price of 1925-30. Consider the results of such changes in price of the leading commodity produced in your neighborhood for sale.

pec, which, however, is not high enough for best coffee growing.

Southward the elevation increases and the plateau of Guatemala and Salvador is an almost continuous coffee plantation from the boundary of Mexico to the boundary of Honduras. Before World War II, Germans owned about half of the Guatemalan coffee plantations. At harvest-time the coffee crop employs half of the population, many of whom work under the all too common Latin American peonage system. Salvador has no lowland to grow export bananas, and hence coffee is by far the chief export. Most of the plantations are owned by the people of the country.

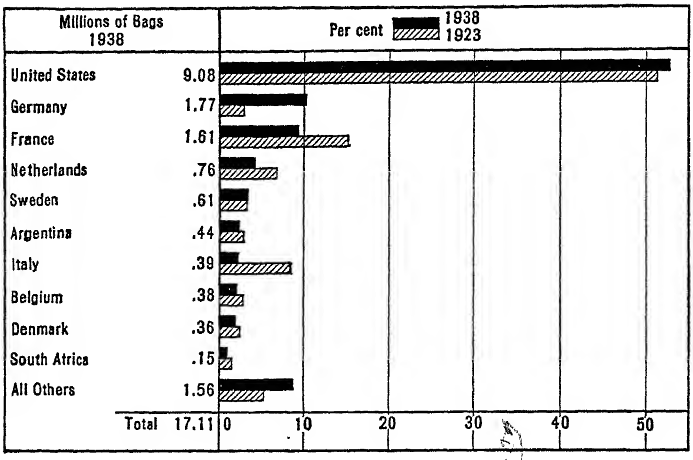
In Costa Rica, the plateaus are even higher, and the coffee tree upon the hillside is the chief means by which the people on this cool plateau secure European and American imports that are brought to them by the little railway that climbs up 5,000 feet from Port Limon, on the Caribbean, to San José, the capital. Costa Rica boasts of being one of the first to use coffee-cleaning machinery. The reputation of their coffee is good.

Venezuela, Colombia and the Andean Highlands. Colombia and Venezuela, being in the hottest part of the torrid zone, have such high temperatures upon their lowlands that few persons live upon them except the few necessary to carry on the commerce between the seaports of the interior plateaus among the northern ranges of the Andes. Here again the valuable bag of coffee, upon the back of the mule as he climbs down to the seaport or the river steamboat landing, represents the best money crop that could be produced in these isolated plateau districts.

Colombia has had a steady increase in its coffee output for the last 30 years, and has now become the second coffee producer of the world. Many plantations have been recently established on the mountainsides between 2,000 and 7,000 feet above the sea. Coffee can be picked throughout most of the year and is the main commercial occupation of most of the people of the country.

Oil from the lowlands is its only rival as an export, and that is owned and operated largely by foreigners. The economic prosperity of most of Colombia depends upon coffee. The same is true of Venezuela, but production is only a quarter that of Colombia, and the oil export is much greater. Small quantities of coffee are also produced on the slopes of Ecuador and on the eastern slopes of Peru, whence it must be carried by mule and railway over the forbidding mountain chain of the Andes.

The West Indies. The coffee tree will grow in nearly all of the West Indian Islands, but the island of Hispaniola (where coffee grows wild), occupied by Haiti and the Dominican Republic, is the heaviest exporter of coffee. In Jamaica the "Blue Mountain coffee," the highest priced coffee in the world, is produced. Its fine quality is due to the alternating rain and sunshine that here last throughout the year on the high mountains, but the crop only amounts to a few thousand tons per year, it is ceasing to be a plantation crop, and is passing into the hands of the small cultivator. Puerto Rico is well fitted by climate, soil, and labor supply to produce the good coffee that was an important export for many years. Before this island was annexed to the United States, the chief market was



Destination of Brazil's coffee exports by percentage two years and by quantity the later year. 132 pounds to the bag. Manifestly, the United States is a coffee-using country.

in Spain, where the Puerto Rican coffee with its peculiar flavor was in demand. When the Americans took possession, the Spanish imposed a tariff upon Puerto Rican coffee, depressing its price, and producing hard times in Puerto Rico. The United States Government has tried to improve the methods of coffee growing and to introduce varieties that would be acceptable in the markets of the United States, but the industry has declined greatly.

Brazil. Brazil is lord of the coffee world, overshadowing all other countries combined, exporting in 1922 about 70% of the world's commercial crop and in 1938 63.5%, after years of struggle to hold down production. Although about two-thirds of the world's crop is produced there, the coffee region occupies but a small corner of this country,[2] which is as large as the United States and Great Britain combined. Systems of railways thread the coffee zone and come down to the two great coffee ports of Rio de Janeiro and Santos. Coffee has long been the backbone of the Brazilian export trade, but we should not overlook the fact that the humble Indian corn is more valuable. The corn is for home use, the coffee is the nation's money (crop). The coffee market of America is practically based on Rio coffee, while Mocha and Java, once names to conjure with, are now insignificant in the coffee trade. Coffee ties Brazil commercially to the United States.

The large and prosperous city of São Paulo, the capital of the Province of São Paulo, is the chief city of the coffee-producing district, which slopes away from the Coast Range towards the Paraná River in the interior. On this plateau, between 600 and 2,500 feet above the sea, are thousands of square miles of a rich red soil capable of producing several times as much coffee as the world needs. The southeast trade

[2] Brazil's aggregate acreage of coffee trees about equals a little more than the area of Connecticut and Rhode Island combined, or 4,133,000 acres.

winds bring from the South Atlantic an abundant rainfall, completing the natural conditions for coffee production.

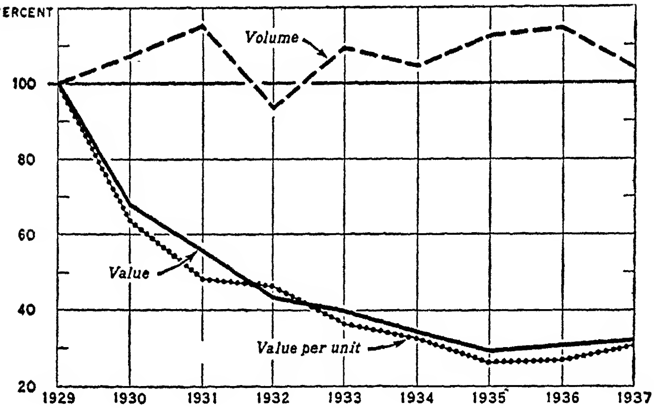
Partly because of this abundance of land the Brazilian coffee estates are often of enormous size. In times of prosperity their owners live luxuriously in the capitals of Europe, while the estates are managed by overseers who employ much Negro labor. For years the Negroes have been leaving the coffee district for life in the cities and on the coast lowlands north of Brazil. Italian immigrants have begun to replace the Negroes.

For many years Brazilian coffee did not bear as good a name in the world's market as that of Mocha or Java, chiefly because of the inferior care bestowed upon the harvesting in a country where efficient labor is more difficult to obtain than it is in Java and Yemen. In Java, the ripe coffee berries are picked off, while the green ones are allowed to remain upon the branch, but in Brazil it was not uncommon for green and ripe berries alike to be swept off the branch by a single motion of the hand, making a cheap harvest but a product of inferior character. Great efforts have been made in Brazil to improve the quality of coffee, especially through the introduction of improved machinery. As this machinery is very expensive, large coffee-cleaning and grading establishments are to be found only in the large towns and on a few of the biggest plantations. Some of the plantations are so large that private railways were built through them to carry the workmen and coffee from one place to another. This is now giving way to trucks. As the land is cheap, careless cultivation prevails, and the heavy rains do enormous damage to the resources of the country by washing away the fertile soil.

Price Fluctuation and Valorization. High prices prevailed in the coffee market from 1887 to 1896, and enormous numbers of coffee trees were planted in nearly all coffee-growing countries. The trees begin to bear in about six years and may yield for thirty or forty more. By 1897 the production was so large that the price fell while the yield kept on increasing until 1902, the industry being influenced by the heavy planting of trees in time of high price and the absence of planting in periods of low price, making alternate booms and depressions.[3] The hard times following the fall of prices in 1897 made great hardship in Brazil, as in all the other regions where coffee was the chief export.

In an effort to restore prices which had gone below the cost of production, the Brazilian Government tried to control the situation. Anyone interested in the record of the attempts at government (monopolistic) control of production of an agricultural product that will store for years will find an interesting record in the attempt of the Brazilians to check the flood of coffee that had glutted the world market. In the boom days, Brazilian plantations were very easy to make. A landowner would let Italian immigrants grow corn in the young plantation for about five years. Thus it cost almost nothing to establish a plantation. Hence, boom, over-plant-

[3] Unfortunately this is a very serious factor in tree crop industries because of the long cycle of the tree.



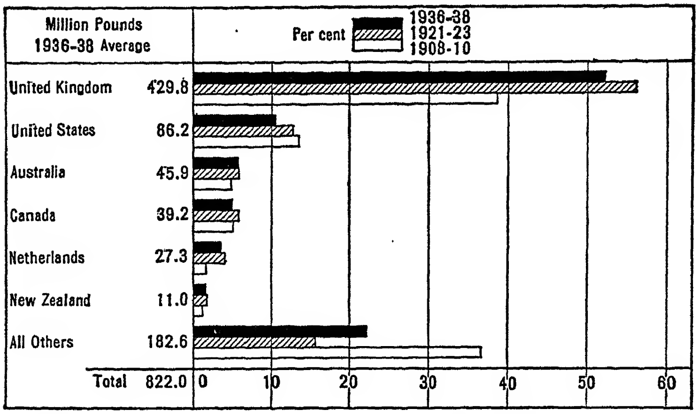
Volume and gold value of the world exports of coffee, 1929 to 1937. Index 1929 equals 100%. This graph might be called the basis of desperation—the quantity holds up, but consider the income of the producer who sold it at 10% of the price he got a few years before. No wonder Brazil burned coffee in her locomotives and dumped it into the sea.

ing, glut, ruinous price. Seeking relief, the Brazilian state of São Paulo prohibited planting, bought coffee, held it for higher price, and became overloaded. The Brazilian Federal Government took up the task, borrowed millions of dollars abroad, bought coffee, held it, burned it to reduce the supply, took it out to the sea, and dumped it—total destruction of millions of bags, amounting to the world's supply for three years. Finally, at the end of more than a third of a century, they gave it up in despair, in 1937, to let nature take its course. When planting was prohibited, the planters began to take much better care of their trees, and production did not decrease as expected. For a time, after a very bad coffee year, the price was high. Then other countries rushed to plant.

During Brazil's long lone struggle to hold down the production of coffee, her exports have remained fairly constant; but the small fry had a good time. Colombia tripled her export. Salvador and Costa Rica increased theirs. So did Mexico. The Netherlands East Indies tripled. Some big Brazilian plantations were sold to farmers who abandoned monoculture, and grew sugar, oil seeds, corn, and cotton, as well as coffee. In the state of São Paulo cotton acreage jumped from 200,000 in 1932, to 1,500,000 in 1935, largely because the United States Government was emulating Brazil's example—in cotton instead of coffee. We reduced cotton acreage. Brazil and other small cotton fry seized the opportunity to boom just as the small coffee fry had done.[4]

The Coffee Supply and the Industry in New Coffee Regions. The fall of coffee prices from the profitable level of 1895 to the unprofitable level that prevailed for more than a decade after 1897, being a world phenomenon, suddenly checked the spread of coffee growing in

[4] See Henry C. and Anne D. Taylor, *World Trade in Agricultural Products,* The Macmillan Co., 1944, pp. 68-80.



World tea import—three-year averages at three periods by percentage and million pounds for latest period. Compare United States and Great Britain in tea and coffee. It might almost be said that tea is primarily the drink of English-speaking peoples, but it is a safe prediction that if Russia gets a good purchasing power, her share will increase.

has to stand, hence the tea only produces adequately where an abundant moisture supply and a warm summer promote growth.

Consumption of Tea. The use of the tea plant has passed through three stages: first, as a medicine; second, as a vegetable (still practiced in Burma and the Shan States); and finally as a bev-erage, beginning about the sixth century, A.D. Its cultivation began at a rather late date in Chinese history, about the ninth century, and it was long the only Chinese export to the western world. Some of the leaf was introduced into England in 1657, and commanded in that country a price of $15 per pound in 1665, but at the end of that century, it was quite common, and Britain with this start became the leading tea-drinking nation. The distribution of the tea habit seems to show a clearly marked influence of national habit and national commerce. Britain began with tea at the very time that she triumphed over her great sea rival, Holland, and her shipping has given her a large part of the world's tea trade as well as its tea consumption. The English-speaking peoples consume three-fourths of the tea which enters international commerce, and the Briton 145 ounces per capita, makes a strong contrast with the one ounce for the wine-drinking Frenchman. Tea has for long been freight for camel caravans passing from China to central Asia, Persia, and Russia. Travelers' reports would make us think that central Asia and Russia swam in tea, but the per capita figures indicate that it was a Russian luxury in 1938.[6]

Chinese Tea Industry. It is impossible to say how much tea is used in China. There are no great plantations in China.

[6] Consumption of tea per capita (in pounds):

United States	.62
France	.07
Germany	.17
Netherlands	2.77
United Kingdom	9.09
Canada	3.44
Australia	6.50
New Zealand	6.60
U.S.S.R.	.21

Source: Ukers, *International Tea and Coffee Buyers Guide*, 1944–45, p. 123.

A few trees in the gardens of many small farmers produce the crop, first for home use, second for export. Europeans first come in contact with it at the ports —a multitude of packs.

Since it is a side crop, they do not pick it if the price is too low. The heavy rains of the summer monsoons give all southeastern Asia one of the prime conditions for the growing of tea.

Most of the Chinese tea is grown in the Yangtze Valley. The mountains between this valley and the Whang Valley are the northern limit of tea.

Chinese tea is usually picked three times a year, the first growth early in April, the second in May, and the third in July or August. The choicest first pickings are so highly prized at home that they are seldom exported; the later pickings of an inferior grade are for the use of foreigners. After the picking, which is usually done by women and children, the leaves are wilted in pans over a fire. They are next rolled into balls by hand to squeeze out the sap, and dried upon screens, care being taken not to let the hot sun burn them. After this, they are further dried by "firing" in copper pans over a fire, being stirred with the bare hands. Inferior teas are stirred with sticks. After this, the leaves are hung up in sacks for a day, then picked over, sifted, assorted, and packed by aid of bare feet into tea chests for export. In some grades of tea, each leaf is rolled by human fingers. The difference between black and green tea is merely a question of curing, although the two kinds are rarely grown in the same locality. If the tea is to be black, rather than green, it is, early in the curing process, piled up in heaps half cured and allowed to ferment, which drives off half of the tannin, of which tea has 10-12%. This changes the flavor and gives a quality that is much desired in many markets.

In the province of Szechwan, one of the western provinces on the headwaters of the Yangtze River, is a very large population, estimated at over 46 million, a number about equal to the population of Brazil. There is a population density of 1,600 per cultivated square mile. They have supported themselves in that inland location for generations by household industries and agriculture, and their tea yield is higher than in the other parts of China. Most of their few exports go down the rapids of the Yangtze to Hankow and Shanghai, but they also send into Tibet some of the worst tea in the world. It is made by cutting off 12-inch twigs of a tea tree, roughly drying them in the sun, chopping them up, twigs and all, sticking all together with rice paste and then compressing the mass into hard bricks for shipment over the fearful passes of Tibet upon the backs of coolies, mules and camels. The greater ease of carrying this compressed form of tea accounts for its shipment by caravan into Russia at an early date. The chief seat of brick tea shipment is Hankow, and while the tea has generally been considered of very poor quality there has been great improvement of late years, and some of the brick tea is now made in that Chinese city under Russian management, and great care is exercised to see that the quality is good. Unlike the Tibetan bricks, this is real tea leaf, pulverized for advantage in transport.

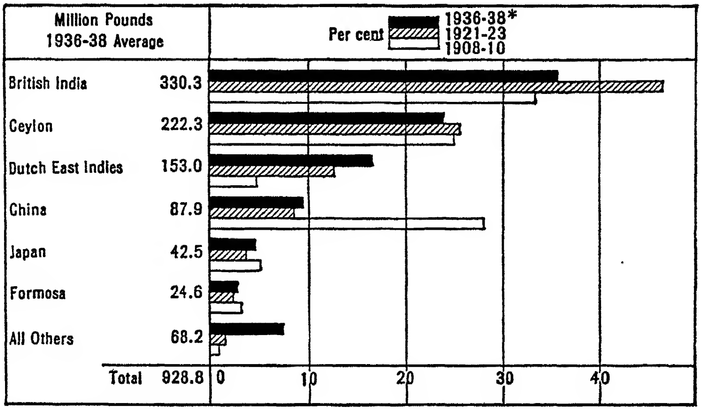
The interdependence of people is well shown by the following series of facts: the collapse of Russia in 1917 stopped

the tea import, making financial embarrassment in central China, checking their power to buy cotton yarn in England, making depression in England, reducing import of pork from the United States, depressing the American pork market and the value of farm lands in central United States. When the record is all told, we shall doubtless have stories like this from World War II. We, the authors, hope readers will send us some.

Japan. Tea requires fertile but well-drained soil along with much moisture, a combination of conditions usually furnished best upon hillsides. This fact, in combination with the large amount of labor required, makes it a crop admirably suited for Japan, where the rainfall is 60-80 inches, and the vast demand for food causes the level land to be prized for rice and grain crops, and makes tea growing in terraces upon the steep hillsides fit in admirably with the Japanese economy. Tea is grown on all the four islands but the tea for export is chiefly grown near Shizuoka. For home use they still prepare it by hand in the old-fashioned way, but for export it is almost entirely cured by machinery. The standard Japanese teas are green, but they had learned to prepare black tea for America which was the chief market before World War II, 24 million pounds in 1938, grown under strict government supervision. In prewar days, thousands of boxes were sent directly to Chicago, St. Louis and other interior points by way of the trans-Pacific steamers which sail from Yokohama to Vancouver, Seattle, Portland, and San Francisco, at which points they connect with the transcontinental American railway lines.

Formosa. One of the best teas in the world, the famous Oolong, is grown by Chinese people in the island of Formosa, which was ceded to Japan in 1895 as a result of the Chino-Japanese War. The recession of Formosa to China at the end of World War II will give an interesting opportunity to watch the tea trade. Oolong used to be grown in the family garden free-for-all Chinese fashion in the Chinese Province of Fukien as well as in Formosa. Since 1923 there has been some development of systematic tea plantations by the Japanese in Formosa. Strict Japanese governmental control of the production in Formosa improved the quality and took most of the trade—with the inferior grades going to China. In the future?—

Introduction of Tea in British Colonies. Chinese teas were practically the only teas in commerce up to 1840. Since that time the world's tea trade has been revolutionized as a result of activities of the British Government in introducing tea growing into India and Ceylon. In the year 1888 the British import of this commodity from China fell below that from the British Colonies of India and Ceylon. Between 1881 and 1905 the Chinese export fell from 300 million to 185 million pounds. In the year 1905 we had the remarkable spectacle of a commission of Chinese experts sent out from the tea-growing province of Nanking to study conditions of tea growing in British India. China had fallen so far behind because her unprogressive tea growers clung to the old hand methods of their remote ancestors, while the rivals under the British flag and the British teacher had attacked the problem in the scientific spirit and with un-



* *Formosa*—1937

World's tea export by percentage, three periods, and by millions of pounds for the last period. China shows the combined influence of lack of uniform product and the Japanese blockade. The high percentage produced by the small island of Ceylon is a good example of specialization.

biased minds and had been using many labor-saving machines.

In 1915 China started a tea experimental farm and school at Nanking but thus far conservatism and war have prevented much success. Internal marketing is poorly organized and before tea reaches exporting firms, it passes through numerous middlemen and pays many illegal taxes, with the result that the producer receives a very low price even for the finest tea. This robs the producer of incentive to produce the best.[7]

Four-fifths of the Indian tea is grown in the northeastern part of east Bengal and Assam, regions tributary to the port of Calcutta. There are at present about 700,000 acres under cultivation in more than 6,000 plantations upon the hills sloping down from the great plateau of Tibet and to some extent in many other places along the southern slopes of the Himalaya Mountains, a district receiving tremendous summer rains. In southern India on the Nilgiri hills is the most important tea district outside of Assam and Bengal. Owing to its low latitude this district produces best at an elevation of from 4,800 to 5,600 feet above sea level, while upon the slopes of the Himalayas the plantations find the temperature that best suits tea at 3,500 feet or less. Figure 555 shows that India is not holding her place in the tea market. Most of the British colonial tea is black and goes to Britain.

European Tea Industry of Ceylon. In contrast to the three large pickings of the temperate zone, the tea of India is gathered every ten days during the period of the monsoon rains in summer, and orchards of Assam like those of Japan average 450 to 500 pounds of tea per acre. On the still more humid hills of Ceylon we find probably the best

[7] Loss of China's export trade is due to: (1) backward method of cultivation; (2) scattered holdings; (3) lack of systematic planting; (4) absence of capital in hands of farmers; (5) complete lack of knowledge of how to maintain quality; (6) unwillingness to improve quality. *Source: Br. Trade Report,* p. 92. But China is not finished yet.

tea-growing region of the world. There it can be plucked every two weeks throughout the year and has yielded 1,000 pounds of dry tea per acre, a quantity 20% greater in actual weight than the average wheat yield of the United States.

Tea growing is a comparatively new industry in Ceylon, having been taken up very suddenly by the coffee planters after the blights had destroyed the coffee trees. In 1867 there were 10 acres of tea, in 1887, 2,700; in 1897, 170,000; in 1904 there were 338,000, but the prices were so low that no new tea orchards were then being set out. The export of tea from this island reached a million pounds in 1883, 148 million pounds in 1900, 182 million in 1910, and has remained at about that figure to the present date. The Ceylonese method of tea growing is typical of the most successful method of prosecuting tropical industries. More than half of the plantations are owned by corporations, and practically all are managed by English superintendents. By this means the average size of the plantation is raised to 300 acres, while in China it is probably a small fraction of an acre. The Ceylon tea plantation work is done by coolies, men, women and children, many of them being Tamils from southern India, and they usually return to their homes across the straits after a period of work gives them a little money. The intensity of the tea industry and its dependence upon a dense population are shown by the fact that less than 600 square miles of tea plantations employ about 400,000 coolies. This is one person to the acre, strong contrast to the American Corn Belt farm of 160 acres, on which the proprietor often has but one hired man for a part of the year to help him grow and harvest 40 acres of corn, 40 acres of hay, 40 acres of oats, grow 20 or 30 hogs, fatten forty cattle and perhaps milk a few cows and deliver some cream to the creamery truck.

Netherlands East Indies. Java has the tea combination of abundant rainfall and cheap native labor (817 per square mile in Java, the chief tea producer). The tea districts are from 2,000 to 5,000 feet above sea level, with most of the estates on the slopes of the volcanic mountains. Many Javanese tea growers do not put all their eggs in one basket. They grow tea *and* coffee, or rubber, or cinchona.

The success of tea in Java has led to experiments on the island of Sumatra, which is now growing fine tea in several districts. Eventually Sumatra, with her more abundant land, might pass Java in tea growing.

The Labor Factor and United States Tea Growing. The vast amount of hand labor in pruning and caring for tea trees and picking and curing the tea explains why the industry has not been developed in the United States, although it has long been known that the tea tree thrives well over an area 100 times greater than all the tea plantations in India and Ceylon, and a number of small attempts have been made.

Tea Districts of Minor Importance. Tea growing has been carried on to a small extent in a number of places throughout a rather large part of the world in which the tree would naturally thrive. Among them may be mentioned Johore in the Straits Settlements upon the Malay Peninsula, French Tonkin, southern Burma, Jamaica, the Fiji Islands, Madagascar, Brazil, Kenya, and

Nyasaland. South Africa is growing about 2,000 acres of tea, principally in the province of Natal, with its fertile slopes facing the Indian Ocean moistened by the southeastern trade winds. In none of these regions has it been an important success, chiefly for labor reasons. U.S.S.R. is the newest tea grower. She had 2,400 acres in 1917, 124,000 in 1938, and expects to have 250,000 in the western Caucasus and western Georgia, and produce 120,000 pounds (compare Ceylon).

Other Teas. The leaves of a number of other plants are locally used as tea in various places throughout the world. In southeastern United States the Cherokees and other Indians dried the leaves of a holly plant from which they made yupon, or "black drink." In Australia the eucalyptus leaf is used. South Africa has a so-called Bushman tea, a grass called lemon grass is used in India, while in the Island of Bourbon Reunion in the Indian Ocean, the so-called "bourbon tea" is made from a dry orchid.

Of all the minor teas the yerba maté or Paraguay tea is the nearest to being a rival of the ordinary tea of commerce. This plant, which is a member of the holly family, grows wild in southern Brazil, Paraguay and Argentina, and is now being successfully grown in plantations and mechanical processes of curing and drying insure uniformity. The summer rains of the yerba belt favor the rapid leaf growth necessary for such a crop. Unlike tea, the bright green yerba leaves are not picked by hand, but the branches are lopped off the bushy trees and smoked over fires until the leaves are dry enough to crumble into powder. The beverage is widely used by the people of Argentina, Paraguay, and southern Brazil. There is plenty of suitable land in northeastern Argentina: overproduction in the 1930's checked planting, and efforts to develop markets in the United States and Europe have not yet produced much result. Production of yerba maté seems to be shifting:

	Brazil	*Argentina*	*Paraguay*
	pounds	*pounds*	*pounds*
1926	263,500,000	28,600,000	21,000,000
1938	208,200,000	159,200,000	31,800,000

3. Cacao

The Confusion of Names. The chocolate and cocoa of commerce are prepared from the seeds of the cacao tree which, because of its name, often gets confused with the coco palm which gives us the large, hard-shelled coconut (often spelled cocoanut). It is also confused with the coca tree, the leaves of which are sent to market from the east slopes of the Andes in Peru and Bolivia by way of the Amazon River or the Pacific ports for the preparation of the drug, cocaine. The word cacao here refers to the dried bean, or seed of the cacao tree.

Origin and Introduction. The cacao tree is a native of tropical America, growing wild in lowland Mexico and in the Amazon and Orinoco River Valley forests up to an elevation of 400 feet. At the time of the discovery of America, it was grown from Panama to Guatemala and Yucatan, and to some extent in the lowlands of Mexico, in which country it was so prized that the dry seeds passed as money among the Aztecs

of the plateau. The Spaniards carried it from Acapulco to the Philippines, and the early exportation of the beans to Spain and Portugal has caused its use to become more general in these countries than among any other European people. The use of cacao is spreading rapidly, as it is a table drink, a soda counter and ice cream flavor, a much prized material for candy, and an acceptable, very nutritious food for travelers and explorers. The table of exports shows that production has soared.

TABLE 26

CACAO EXPORTS

(In metric tons)

	1898	*1909–13 (average)*	*1922–26 (average)*	*1927–31 (average)*	*1935*	*1938*
Gold Coast	188	34,905	207,161	231,791	265,227	236,259
Brazil	12,943	31,644	61,464	71,244	111,826	125,000
Nigeria	35	3,403	37,611	49,912	89,553	97,542
Ivory Coast	....	19	4,676	16,154	43,565	52,719
Dominican Republic	3,993	18,274	21,105	22,691	28,355	28,200
Cameroons	209	3,855	7,328	9,406	23,375	27,677
Venezuela	9,572	16,052	19,599	18,050	15,042	20,600
Trinidad	11,462	22,586	25,463	25,659	20,134	19,504
Ecuador	21,089	37,354	32,607	19,879	20,198	18,451
São Thomé	9,945	35,412	17,781	14,751	10,884	12,729
Costa Rica (ranks 13 in 1938)	20	29	3,998	5,805	5,071	5,530

Source: British Board of Trade, *Economic and Statistical Study of World Position of Cacao,* January, 1943, Appendix I.

Exacting Climatic Requirements. The climatic requirements of cacao are exacting. The tree, which is 15 to 40 feet high, requires more heat than coffee and yet cannot stand the full blaze of the tropic sun, and so is grown under the shade of taller trees, the young plantation being sometimes shaded by corn or bananas. It requires much moisture with soil rich and deep so that it is almost always grown upon low plains. The valuable seeds of beans, to the number of 30 to 60, are produced in a greenish or reddish pod, 3 or 4 inches in diameter and 6 to 10 inches long. As this heavy, cucumber-shaped fruit is attached in clusters to the trunk and larger branches of the tree, and since a strong wind beats the immature pods about until they fall useless to the earth, the area over which cacao can be a profitable crop is greatly limited. In regions of tropic typhoons (hurricanes), or even where strong winds blow the cacao tree cannot be depended upon as a source of financial income. This affects most of the West Indies where cacao can be grown only in valleys protected from the wind, as in rugged parts of Trinidad, Jamaica, Grenada, St. Lucia, and the Dominican Republic. A level island, like Barbados, exposed to the steady trade winds, cannot produce it.

The tree begins to bear at the age of three years, but does not reach its maturity until it is ten or twelve and may bear for thirty or forty years more.

Importance of the Doldrums or Zone of Calms. Near the equator in all continents is a zone of calms, called doldrums, lying between the two trade wind zones and drenched with frequent and heavy rains. In this belt, at no place more than 13° north or south of the equator, are found the most important cacao districts. The Asiatic and Australian monsoons cause seasonal winds to sweep over the East Indies. These islands do not appear in Table 26.

Ecuador. Ecuador was long the greatest cacao-shipping country. The low plain upon the western coast of that country is crossed by the equator, where the doldrum rains and evergreen forests make it a striking contrast to the trade wind deserts upon the same coastal plain in adjacent Peru. As with the banana, plowing is not necessary, the only care being enough chopping to prevent the smothering of the young trees. The mid-slopes of alluvial fans along the mountain front easily became cacao orchards. Cacao exports dominated foreign trade and internal economy for a century. Then in 1916 a disease, monilia, attacked the fruit, and to make it worse another disease, witches'-broom, attacked the trees. Note the export figures, and you have the record of a country in distress. The government has established an experiment station to study the industry, but tropic tree diseases are hard to fight. The witches'-broom spread to Trinidad (see Table 26). Meanwhile the seeds had been carried to Africa with startling industrial results.

Ecuador and Brazil Compared. Cacao growing is not a comfortable business and it takes large profits to tempt men to do it. The Ecuadorean growers all desire to live elsewhere. The climate of the cacao forest is unwholesome to the white man, the jungles swarm with dangerous animals, poisonous serpents, and pestiferous insects. Fevers are common, and labor naturally is scarce. Although sparsely settled, the low plain of Ecuador is populous in comparison to the empty jungles of the Amazon Valley of which Ecuador, Peru, Colombia, and Bolivia each own an area greater than the Pacific Plain of Ecuador. Most of the Brazilian crop comes from the Atlantic plain 50-100 miles wide in the state of Bahia.

The West Indies and Caribbean Countries. The British colony of Trinidad, lying below the hurricane belt, has many protected valleys lying between the spurs of its mountain backbone. This valuable bean is also important in Venezuela, where it is grown in valleys in northern and northeastern mountains.

A little cacao is grown in many West Indian Islands and throughout Central America, but it is chiefly for local use, except in Costa Rica, where a disease wiped out many banana plantations and left labor glad to get a job and the forested plain suits cacao.

Old World Cacao Growing. Cacao, being a native of America and only recently of importance in commerce, has not been grown long in the Old World, but the greater labor supply of the Old World tropics now enable those regions to outstrip America in the export of the precious bean. Thus, the Gold Coast (British West Africa), which

stretches for 334 miles along the Gulf of Guinea, has developed this new and valuable tree crop agriculture as its leading industry. From less than 6,000 tons in 1905, the output of this newly introduced crop reached 307,000 tons in 1936. The spasmodic labor of cacao growing suits the tropic denizen. There is no rush to market as in bananas. The dried beans keep well. There is no expensive machinery to clean as in coffee. Take a basket of cacao fruits. Sit on your heels, cut them open with your machete, pick out the beans with your fingers, put them in a pile to ferment, dry them on a bamboo tray which you yourself have made. If rain threatens, carry the tray into your grasshouse. You soon have a hatful of beans to sell or eat, even if you don't have a hat to put them in.

Thousands of African patch farmers have a few acres in cacao trees. The Colonial government encourages, enforces grades, builds roads and behold! A million acres now are in cacao in the Gold Coast alone, and two-thirds of the people have a hand in it.[8] The same process goes on in Nigeria, Ivory Coast and the Cameroons.

Insignificant quantities of cacao are grown in Java and Ceylon. Its growth has been begun in Samoa and other Pacific isles, but the population there is insufficient for the production of a large surplus.

Method of Preparation and Use as Food. After the cacao pods have been severed from the tree by means of a knife, perhaps on a long pole, they are cut open, and the seeds, which are covered with a slimy pulp, are taken to the sweating house for fermentation. This process in the course of a week disposes of the pulpy seed covering, and they are then ready for drying in the sun or by hot air furnaces. When carefully fermented the seeds are twice as valuable as when carelessly done.

Cacao differs from tea and coffee in the manner of its use. The latter are used as decoctions made by steeping or boiling the tea leaf or coffee berry in water, after which the leaf and berry are thrown away. Cacao, containing the same stimulating principles as tea and coffee, has in addition many food elements and is, therefore, a food as well as a stimulating drink. All processes of manufacture merely grind up the red-colored beans. This grinding may be done in the kitchen as do the Chinese cooks in the Philippines who pound the beans in mortars and flavor them with spices to suit individual tastes. In the western world the beans are taken to the great factories of Holland, England, France, Germany, Switzerland, or the United States, where expensive machinery pulverizes the beans to great fineness, mixes the powder with sugar, various flavors, natural or artificial, and sometimes also with milk. This use of milk requires many chocolate factories to be near dairy centers and it even causes the location of some plants in the country towns of dairy districts, as in eastern United States and Switzerland.

The so-called breakfast cocoa differs from chocolate by having a part of the nourishing fat, or cocoa butter, removed to make it more easily digestible. This

[8] During World War II, the exports dwindled, but cacao did not. The market promised to glut absolutely and bankrupt the African colonies. Therefore the British Colonial office bought the cacao at the ports and burned it. Then to save work, they burned it at point of production. Abundance is the devil of our system of distribution.

fat comprises about 50% of the bean, but various grades of cocoa have from 10-22% fat. The fat is valuable in medicine and has the peculiarity of never becoming rancid no matter how long it is kept. Examination of the data in Table 22 and the comparison of chocolate with our staple articles of diet will show its great value as food. It is several times as nutritious as eggs and about two and one-half times as nutritious as beef. These are significant facts when taken in connection with the relatively declining quantity of beef, and its increasing price. The cost of cacao production is estimated as low as 4 cents a pound, and the fecund tropics can increase the supply indefinitely to meet the demand—quite different from the meat situation.

The growing fondness of Americans for chocolate and cocoa in its various forms is shown by a more than tenfold increase in the import of the cacao bean within the last 40 years.

4. Spices

Despite their non-nutritious character spices are so generally prized as an article of diet as to be of nearly world-wide demand. In the history of commerce they are of especial interest because the trade in spices long dominated the commerce between the East and the West. They were for centuries the only food products that could be transported far, and they were of greater relative importance in the diet of ancient and medieval peoples because the small variety and poor flavor of their food made a greater necessity for something to improve its palatability.

Spices the Product of Tropic Garden Spots and Hives of Population. Practically all the spices with the exception of mustard are limited in their production to the tropics. The trees and fruits from which they are produced have been widely disseminated throughout the hot countries, their growth is usually common, but the commercial production of the spice rarely follows the mere introduction of the plant for local use. This is due to the fact that nearly all the spices are like tea in requiring tedious and painstaking labor in their production. As a result their export is limited to centers of dense population and good labor supply. It was the spice trade that Columbus sought, and spice trees were among the early introductions to the New World. While the New World gave the Old World grains and cattle and now dominates in the export of these products of sparse populations, our export of spices yet remains insignificant.

Pepper. This is the most important of all spices. It is prized alike by rich and poor in both tropic and temperate latitudes. In quantity it equals all of the others combined. For years Singapore has been the greatest pepper-exporting port. Most of this export is assembled from Malacca, Java, Sumatra, Borneo and Siam. Much of it is grown by Chinese workers. Netherlands India produces 85.7% of the total export, Indo-China 6.5%, Sarawak 4.4%, India 2.8%, Madagascar .3%, and Siam .3%.

Black pepper is the dried, unripe seed of a climbing vine and the white pepper is the same seed riper and with the skin peeled off. The common method of growing this plant is to sow the seeds in fields of rice, castor beans, and other

temporary crops. At the same time the seeds of rapidly growing trees are sown. In two years these trees are cut and stuck in the ground as poles, making a permanent support for the climbing pepper vine, which yields its crop after a three-year wait and is expected to produce for 10 more years.

Cayenne pepper or chillies is an entirely different plant, yielding a small fruit something like the peppers commonly seen in temperate-zone markets. It is widely grown for local use throughout tropic Asia and Africa and in South America, and properly takes its name from the city in French Guiana.

Ginger. This, the second spice in the order of demand in the market, is the underground stem of a reed-like plant growing wild in the warm parts of Asia. It is one of the most widely cultivated spices. It is planted like any common crop, dug in ten months, and like most spices, dried in the sun. It is exported from British West Africa, China, Jamaica, and British India.

Cinnamon and Cassia. Cinnamon is the bark from young shoots of a small evergreen tree native to Ceylon and the adjacent coasts of India. It was a government monopoly in Ceylon until 1833. Since that time it has been introduced in Java, Cape Verde, Brazil, West Indies, and east Africa, but almost the entire supply is still produced in certain districts of southeastern Ceylon where 25,000 acres are under cultivation. This island has the necessary warmth, moisture and light sandy soil, and over most of its territory a population ranging in density from 200 to 600 per square mile, thus furnishing the labor necessary to keep the cinnamon trees trimmed to a low bush-like form, to gather the long shoots, peel the bark from them and dry it ready for market. The flavor of cinnamon, like most of the spices, is due to an essential oil. Cassia, the bark of a somewhat similar plant, is much like cinnamon, is gathered in the same way but is of inferior quality, and is largely used to adulterate the Ceylon article. In the United States we use 20 times as much cassia as cinnamon. Most of the cassia is produced in the tropic part of south China, and the exports are sent out through Hongkong.

Nutmegs and Mace. Mace is the husk around the nutmeg, the fruit of a tree growing wild in the Banda Islands in the East Indies. This spice tree, with the clove, was long a monopoly of the Dutch Government in the Moluccas or Spice Islands, where the Dutch traders in the days of their commercial supremacy preserved their spice monopoly by sailing the eastern archipelagoes and cutting down spice trees wherever they found them. Nutmegs and mace are now chiefly grown for export in Netherlands East Indies and the islands of Penang, East Indies (110 square miles, 2,466 people per square mile), and Grenada, West Indies (133 square miles, 665 people per square mile). The population of Penang is largely Chinese, which conduces to production. In addition to nutmegs, the little West Indian isle of Grenada exports lime oil and bananas.

Cloves. This hot spice is the dried, unopened flower bud of a tree grown chiefly (85% of world supply) in the islands of Zanzibar and Pemba off the eastern coast of Africa (total area, 1,020 square miles; pop., 250 per square mile). The large plantations are owned mainly

by Arabs of which there are about 10,000. These islands, over 3 million trees in bearing, produced over 23 million pounds in 1938-39. The oil of cloves is often extracted from the spice and sold as a separate product. Madagascar is the only other important producer of cloves.

Vanilla. Vanilla differs from the other important spices in being a native of America, Mexico. It is cultivated to a small extent on the eastern coast of that country, but this cultivation is practically captured by the Oriental labor supply, situated in the Indian Ocean islands of Madagascar, Reunion, Mauritius and Seychelles, and in French Oceania.[9] The growth of vanilla is very exacting. It is an orchid-like vine and must grow in the shady and humid forests. Owing to a peculiarity of the blossom, each one must be fertilized by means of a small splinter of wood in the hand of the attendant. After the beans are ripe, they must be most carefully dried to maintain the perfect flavor.[10] It is estimated that the United States takes about one-third of the world's vanilla.

Pimento or Allspice. This fragrant spice is the small dried and wrinkled fruit of a beautiful tree which grows to 30 feet in height, is a native of tropical America, and cultivated chiefly in the island of Jamaica (population over 275 per square mile in a mountainous territory). The pimento trees commonly grow in pastures, and at picking time small boys climb the tree and break off the fruiting twigs. Women pick them up from the ground and attend to the work of drying and preparing the fruits for market.

Mustard. Mustard is the most popular and extensively used spice in Great Britain, and is quite generally used in other countries. It is the finely powdered seed of a plant belonging to the same family as the turnip and beet. The production of this seed is quite widely scattered, and seems to be centered in localities possessing the necessary foggy climate that favors its best development; thus certain foggy districts in Essex and Cambridgeshire, England, and in Holland have developed a mustard industry.[11] The United States had its first successful mustard district in Santa Barbara County, California, in a valley opening directly to the Pacific, whence come the necessary fogs at the ripening time. Montana has at last learned to grow it, and World War II gave it a boom. Production (in thousand pounds) in 1938 and 1942 was: California 2,600-4,500; Montana 15,000-34,000.

An inferior quality of mustard is also exported from Bombay, India, where the climate renders the seed too hot to be generally acceptable.

5. *Tobacco*

The Use, Spread, and Consumption of Tobacco. No textbook for use in Europe or America need tell of the uses of tobacco, except to refer to some of the industrial services such as the utilization of tobacco waste as insecticide and as fertilizer rich in potash. Colom-

[9] The official estimates of the vanilla production 1935-39 average were as follows: Madagascar and dependencies, 895,000 pounds; French Oceania 273,000 pounds; Mexico 204,000; Reunion 110,000; West Indies 3,200; World total 1,548,000 pounds.—U. S. Dept. of Commerce.

[10] The natural vanilla flavor is produced by vanillin and other substances in the bean. Synthetic vanillin is made from oil of cloves, hardwood tar, wood pulp waste.

[11] Baltic lowlands near Königsberg were important centers of production before World War I.

bus and his fellow discoverers found tobacco in use among the American Indians. When carried back to Europe, its use was opposed by priest, pope, king, and emperor, and the czar of Russia once laid even the death penalty upon its use. Doctors and athletic coaches oppose it, but none the less its use has spread faster and farther than any language or religion and is found throughout the realms of civilization and barbarism.

TABLE 27

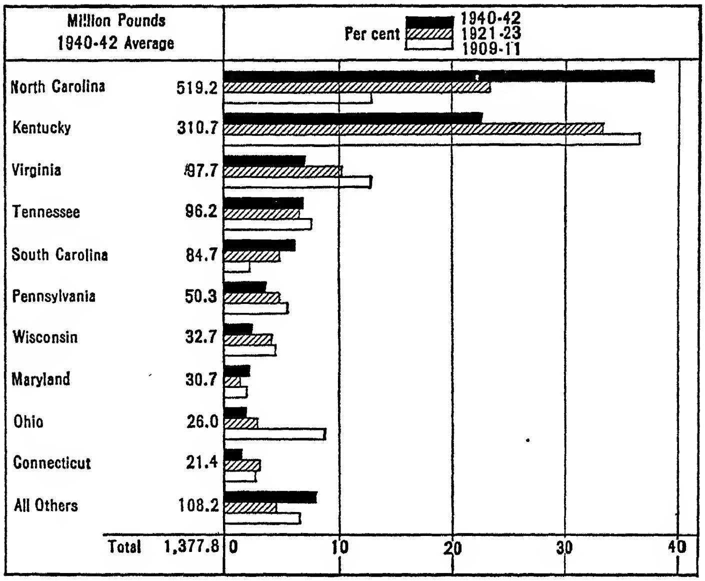
PER CAPITA CONSUMPTION OF TOBACCO, POUNDS

	United States	*Germany*	*France*	*Great Britain*
1861–65	1.6	2.8	1.7	1.2
1886–90	4.6	3.3	2.0	1.4
1906–10	5.1	3.6	2.4	2.1
1923	10.4	4.3	3.0	3.8
1932	6.1	3.2	2.9	3.3
1943	8.7	...	...	...

It really took possession of this nation when the machine made cigarettes by the mile and cut them off in lengths, and the advertisers, discovering that we were but guinea pigs, took charge of our habits. Here are the figures: United States cigarette consumption—1913, 15 billion; 1923, 63 billion; 1944, 324 billion. The depression of the 1930's could not check the advance in consumption. Even the numerous enemies of tobacco, either on moral or on economic grounds, cannot ignore the tremendous part it plays in our national production and industry.

Few commercial plants grow over so wide a range of the earth's surface. It is injured by frost, but it grows in a comparatively short season, so that profitable crops ripen as far north as Wisconsin, southern Canada, and England, while it is at home throughout the tropics. Probably no other commercial product possesses more grades and commercial varieties. One field of Sumatra tobacco may be classified into as many as seventy-two different market kinds. The quality of the soil affects it in a remarkable degree, as does temperature, humidity, the seed, the method of cultivation and fertilization, and especially the fermentation and chemical changes that take place in the process of curing the leaf. The green leaf is cured in barns on the farm and then, for some uses it cures in hogsheads for a year or two or three. The resulting strength or weakness of flavor, the kind of flavor, the thickness, brittleness, elasticity, texture, color, size, perfection and relative weight of leaf, its specks, its dustiness, gumminess and ripeness are some of the factors that decide whether the tobacco will bring two cents or $2 per pound.

Tobacco's Commercial Service. The commercial service of tobacco has been great. The Jamestown Colony in Virginia was about to fail in its early days because the settlers could find no money crop, nothing to sell to the mother country in return for the imports that they must have. England, being then essentially an agricultural land, had an abundance of wheat, oats, barley, rye, and all agricultural staples as well as manufactures. The company that founded Jamestown imported Italian experts and tried to grow silk, but failed. The European grape also failed, and with it went their hopes of a wine industry, and the colonists had been depending on those



Tobacco production in leading American states—three three-year periods and quantity for the latest period. Interesting study in increases and decreases.

two luxuries, for which there was a good market in England. Despair ruled in Jamestown and talk of returning to England was rife. Then a trial shipment of tobacco which the Indians had shown the colonists how to grow brought a good price in England and spread industrial hope in Virginia where there was unlimited land suitable for tobacco. It promptly became the great staple of trade, remained so throughout the whole Colonial period and to a very considerable extent down to the present time. It was so important as to become a standard of currency in the Colony of Maryland in 1722, and the clergy and all other public officials received their pay in tobacco. As late as 1810 it was one of the few crops that could be sold by the people of Kentucky and Tennessee, whose export market was New Orleans reached by non-returning flatboats down the Ohio and Mississippi Rivers. At the founding of our government its export of over 100 million pounds was one-fourth as great as it is now.

Tobacco Injury to American Soils. The ready market for tobacco in Europe has resulted in great injury to the soil resources of most American tobacco-growing districts. For centuries it had been the custom of European planters to raise wheat or other winter grain, such as rye, one year, followed the next year by spring-sown grain, like oats or barley, and the third year the land was plowed and let lie idle or fallow, before entering again on the three-year rotation. But in America the crop of tobacco took the place of the fallow year and, because of the good profits, tobacco was even grown year after year until its great demands for potash exhausted the soil for a time, and the field was often abandoned because land was so cheap that more could be had by cutting down

This photograph, taken in the rain, shows how tobacco rows planted on the contour (rows level) hold the water and give it a chance to soak into the ground. If the rows had been up and down the hill we would have had loss of water and of soil, a process which has cost us millions of acres of good land and is still costing us tens of thousands of acres every year. The effective United States is getting smaller.

and burning the forest. Then the heavy downpours of the summer thunder showers sometimes reduced the naked tobacco field to useless gulleys before the briars and old field pine could again make a forest there. This wasteful policy brought great poverty to southern Maryland and middle Virginia, and from these sections the people emigrated in such large numbers shortly after the Civil War when western farm lands were opened up, that there was a general loss of population throughout the old Colonial tobacco district, which today has fewer people and less land in cultivation than it had a century ago. As regards potash, tobacco is the worst of soil-robbers, although the destruction of soil fertility does not necessarily follow if proper crop rotation is practiced. This has been proved in many places, notably by the farmers of Lancaster County, Pa., and other parts of that state, where splendid crops of tobacco are grown on small farms producing corn, wheat, clover, and cattle, the tobacco being grown on the same land only once in a period of six or seven years. For the three years 1921-23 the average yield per acre in Pennsylvania was 1,360 pounds; in Virginia but 680 pounds.

Table 28 suggests that careful Pennsylvania had reached the top 25 years ago, and that Virginia has become more careful—and applied more and better fertilizer. The table also shows a situation that is very common with major crops—high yields and heavy production occur in different places.

TABLE 28

Yield per Acre of Five States Having Highest Yield per Acre, Irrespective of Total State Production

State	3-year average 1942–44, lbs.	Production 2-year average 1942–43, 1,000 lbs.
Massachusetts......	1,625	8,641
Wisconsin..........	1,515	28,172.5
Connecticut........	1,389	19,950.5
Pennsylvania.......	1,355	41,067
Indiana............	1,145	9,509

Yield per Acre of Five Leading Tobacco-producing States Ranked by Production

State	3-year average 1942–44, lbs.	Production 2-year average 1942–43, 1,000 lbs.
North Carolina.....	1,027	563,506
Kentucky..........	1,026	310,130
Virginia...........	1,013	106,783
Tennessee..........	1,057	93,085
South Carolina.....	1,055	91,615

TABLE 29

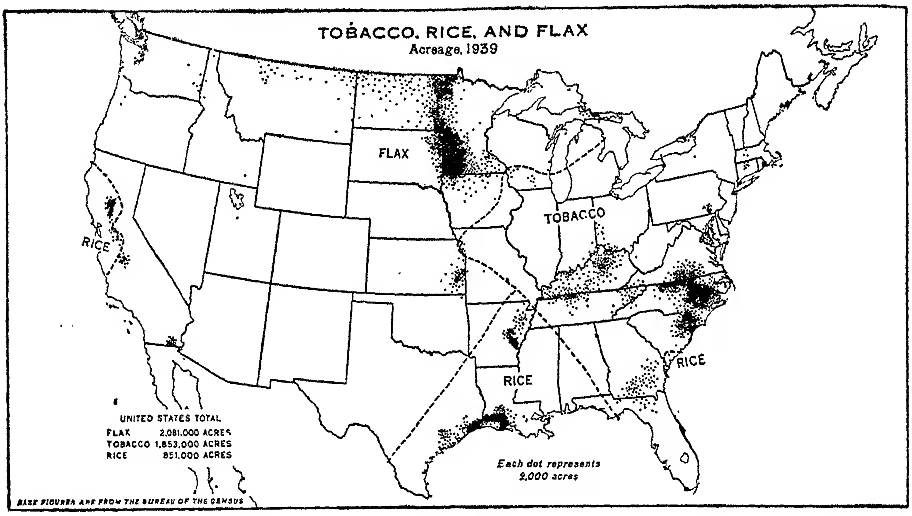
	Farm value per acre, U. S., 1939 average	Acres harvested in U. S., 1939	Farm value of U. S. crop, 1939
Tobacco...	$144.47	1,999,900	$288,918,000
Wheat....	9.73	52,668,000	512,401,000
Hay.......	9.92	69,097,000	685,427,000
Corn......	16.60	88,279,000	1,465,075,000

Source: Agricultural Statistics, 1942.

Tobacco an Intensive Crop. Because of the great amount of labor in its production, a pound of tobacco is worth many times as much as a pound of hay or grain. It belongs to intensive agriculture (see Table 28). The tiny black

This tobacco curing barn illustrates one of the processes that makes tobacco growing an intensive industry. The leaves are fastened on sticks, then taken from the field to the special drying barn, and hung up so that air can pass through them. This is called curing and it may be well done or otherwise.

seeds, three or four hundred thousand to the ounce, are sown in seed beds, and until the invention of a planting machine in this century, the little plants were transplanted by hand to their place in the field, where constant attention and hand labor are still necessary to protect them from the cut worm which cuts off the young plant, the leaf worm which eats holes in the leaves, the stalk worm which destroys the central stalk of the plant. The blooms must be picked off, so that the energy may go to leaf

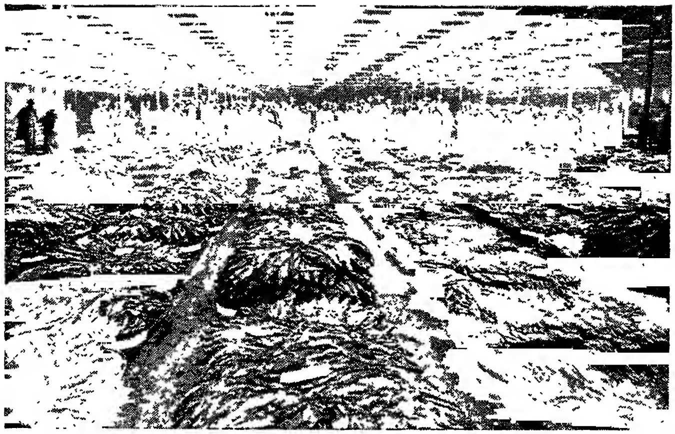


The map of tobacco growing shows how tobacco centralizes in contrast to wheat and corn which are widely scattered.

rather than seed. For the same reason, the suckers or side shoots must be pulled off, while the process of picking, curing, sorting, grading, and packing is laborious and requires skill. As much of the labor of tobacco growing requires watchfulness and care rather than strength, it can be done by women and children as well as by men, and as a result it is rarely grown on an extensive scale and is usually grown by the members of the farmer's family (often tenants), who call for a small field. The tobacco farmer of Virginia and Kentucky usually raises enough corn to feed the horses that work his lands, the pigs that make his meat, and the cow and chickens that help feed the family. He sometimes also raises some other supply crops, but all his money he usually expects to get through the sale of tobacco. From the social standpoint, this sharecropper system leaves much to be desired.

The Leading Tobacco Belts of the United States. For a long time the Virginia-Carolina tobacco belt, running from southern Maryland through the middle part of Virginia and North Carolina, and on into South Carolina, has been the leading tobacco belt of the United States.

The limestone lands of Kentucky are the chief seat of tobacco production, which makes Kentucky the second state. Lexington, Kentucky, is the largest loose-leaf tobacco market in the world. It is brought to great auction rooms by the growers. Wilson, North Carolina, is the greatest fine-cured tobacco market. Much Kentucky tobacco is exported to European countries, for the United States is by far the greatest exporter as well as the leading tobacco grower in the world, surpassing China and India which are often close rivals in output. Large amounts of tobacco are also manufactured in Louisville. In the eastern field, Richmond is the greatest cen-



A tobacco auction in a tobacco market—a town central to many tobaccco farms. Each pile has been numbered and weighed—and the paper shows the record. Buyers can inspect at leisure so that they may bid intelligently on the day of the auction. Note the size of the building.

ter, while Petersburg and the Carolina towns of Winston-Salem and Durham have enormous tobacco factories where, by very complicated machinery, cigarettes, smoking and chewing tobacco, and snuff are manufactured for shipment to all parts of the United States and for export.

The Minor Tobacco Belts of the United States. The growing of tobacco is widely scattered in this country, small but important tobacco-growing districts being found in the Connecticut River Valley of Connecticut and Massachusetts, in southern Wisconsin, in Louisiana where the famous "perique" is grown, and since 1884 in Florida. Experiments with the seed of the high-priced Sumatra tobacco showed that with shade it would grow well; consequently fields are so planted that thin cotton sheets can be placed over them to soften the rays of the sun and make a more even temperature and more uniform humidity. Despite this great expense the business has proved profitable in Connecticut and Florida. Cuban tobacco as well as the Sumatra has been grown in Florida, and the artificial shade method has been copied in Cuba and Puerto Rico. The effect of these innovations is shown in an acreage value in Connecticut of $1,038 in 1943, while the great crop of Kentucky averaged but $403 per acre.

Our Import Needs. The fact that the United States is the world's second largest producer and leading exporter of tobacco does not mean that we supply all the requirements of our own people. We are large importers of three distinct classes—cigar tobacco coming mainly from Cuba and Puerto Rico; wrapper tobacco from the Dutch East Indies; and certain types of cigarette tobacco chiefly from southern Europe and Asia Minor.

Tobacco in Cuba and the West Indies. Cuban tobacco is famed throughout the world for its fine flavor, being much prized for cigars, and chiefly used in the manufacture of the famous Havana

cigars. The amount produced is about half as great as that of South Carolina, which ranks fifth in United States production. The Havana tobacco is the peculiar product of the south slope of the Sierra de Los Organos, a mountain range running from east to west throughout the whole length of the province of Pinar del Rio in the west end of Cuba. Tobacco is the one means by which the people of this district, called the Vuelta Abajo, are now able to buy products of the entire world. Innumerable attempts to grow the same tobacco in other parts of Cuba and other countries have resulted in failure, the nearest approach to success having been the shade-grown Florida product. The secret of its high quality is not known. It may be the protection from northern winds or some quality of soil or some effect of fermentation in curing. Most of the Cuban tobacco is used for cigars and Havana is a great cigar-manufacturing center.

The American tariff on imported cigars and tobacco has caused the building, largely by Cubans, of the cigar-manufacturing city of Key West on a little coral reef, 90 miles from Havana, the nearest spot in the United States to which the Cubans could move to take advantage of the high price created by our tariff. From Key West the industry spread to Tampa, where in 1910, 56% of the people were in the cigar industry. In 1930, the figure was only 25%. Connecticut shade-grown wrappers competed with Cuban. The cigarette competed with high-priced cigars, and factories moved to Trenton and Passaic, N. J.

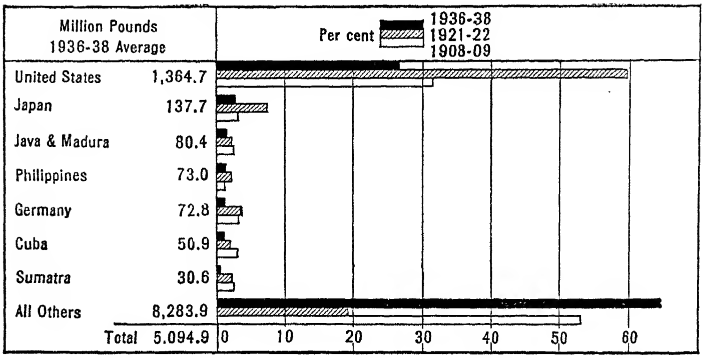
Tobacco is also exported from Puerto Rico and from the Dominican Republic on the east half of Hispaniola.

Tobacco in Sumatra and the Orient. Sumatran tobacco is like the Cuban in being of high value. Its thinness and elasticity give it great excellence as cigar wrappers, while the Cuban excels as cigar filler. The growth of Sumatran wrapper tobacco is due entirely to the enterprise of Dutch financiers and managers, a single company of Dutch capitalists having employed in the island of Sumatra as many as 16,000 Chinese with 200 skilled European overseers.

World War II interfered with this business, but in 1950 it was continuing with smaller output of the same high quality as of old. Most of the Sumatran product is grown on the eastern plain on tribal lands held on long leases. The passage of time has caused a decline in the proportion of European and Chinese necessary to keep the native worker maintaining a high quality of output. The high quality requires equatorial humidity and the absence of storms. The same climate is simulated in Connecticut by erecting a thin cotton cover over the tobacco fields. The Dutch company that controls Sumatran tobacco now has its headquarters in a Connecticut town.

At times India produces more tobacco than the United States does, but it only amounts to 3.8 pounds per capita and but little of it is exported. Japan grew about 2.5 pounds per capita, 1939-40, but it was all kept at home and some was imported. Its growth for local use is quite general throughout western and southern Asia.

The Philippine tobacco bears the same reputation in the eastern world that the Cuban tobacco does in the western world, and the export nearly equals that of Cuba. The best of it is grown in



Production of tobacco by three three-year periods by percentage, and by millions of pounds for the latest period. The two great home market producers, India and China, are not here shown. The fame of Cuba and Sumatra results from quality not quantity.

the northern Province of Luzon in the valley of the Cagayan River, which keeps the tobacco lands perpetually fertile by the layer of mud deposited in the annual overflow. This tobacco is shipped from the port of Aparri to Manila, where many persons are employed in making it into the well-known Manila cigars. The poorer tobacco from the southern Philippines is sent to Spain.

European Tobacco Production. Tobacco is grown in France, Germany, Italy, and many other parts of the continent of Europe, but on account of large population, the quantity is usually insufficient for local use. In 1936, Germany had an acreage yield more than double that of the United States.

Nearly all of the Danube Basin and Balkan countries are tobacco growers; it is an important crop in Hungary, Bulgaria, Rumania, Yugoslavia and Greece. Some of the choicest grades of Turkish tobacco are raised in the provinces of Bosnia and Herzegovina in Yugoslavia; wherever a small patch of level ground can be found among the limestone sinks, soil is collected and protected from erosion by stone barriers. Greece is the only important European exporter, her mild-flavored Turkish tobacco, grown largely on the plains of Thessaly, going to Germany, to the United States, and to Egypt to use in cigarette making. The so-called Egyptian cigarettes, one of the principal manufactures of Cairo, are made entirely of imported tobacco. The growing of tobacco is prohibited in Egypt, and she must depend on Greece, Russia and Asia Minor for her raw material.

France is fostering tobacco growing in her African colony of Algeria, and the export of Algerian tobacco is increasing.

Tobacco Monopolies. Of all the well-known agricultural products tobacco has probably been the most subject to government regulation and control. Tobacco and alcoholic beverages seem capable of bearing great burdens of taxation.[12] To aid this revenue collection England has long prohibited its growth.

[12] Four general methods are used in collecting such revenue: Government tobacco monopolies, internal-revenue taxation, import duties, and export taxation. Latin American countries have re-

South American Tobacco. Brazil grows enough tobacco along her eastern coasts for her own large home consumption, and an export (80 million pounds) that makes her the third tobacco exporter of the world. Ninety per cent of the export is shipped from Bahia, where the foreign commission houses advance the money to the growers, who are always in debt, and take the crop in payment for the loans. It is not grown on plantations, as in Sumatra, but by the families of small farmers who get but 300 pounds per acre—a very low yield (Pennsylvania 1,355 pounds).

Colombia has a small tobacco export which is an interesting illustration of the commercial service of the plant. In some districts in Colombia, tobacco, wrapped in bales covered by one or two layers of raw ox hide, survives the humidity of the climate, the downpours of frequent rains, and the hardships and costs incident to weeks of ox-cart and mule-back transportation en route to railroad or riverboat.

The people of Paraguay, men and women alike, are among the greatest smokers in the world; the rich soil of this subtropical country is supplying not only the local demand but providing an export crop of growing significance. From Argentina to Central America and Mexico tobacco growing for local use is common.

World Trade in Tobacco. In 1938 Bremen had long been one of the great tobacco markets, distributing it throughout Germany and many of the other countries of Europe. Amsterdam is the headquarters for the companies owning the tobacco plantations in Sumatra and Java, and practically all the export of the Dutch East Indies (total, 108 million pounds, 1938) goes to Amsterdam for distribution. The same is true for much American tobacco. In 1938, 41.8% (489 million pounds) of the tobacco entering into world trade went from the United States, while the Dutch East Indies furnished 9% (108 million pounds) and Brazil 5% (59 million pounds). The United Kingdom and Germany were the heaviest importers, with 234 and 212 million pounds, respectively. The British tobacco market is supplied almost entirely from the United States. There is good prospect that Britain, almost bankrupted by the war and with imperative need to import, will soon discover that she can grow most of her tobacco in a very small corner of land, as she had once grown enough tobacco for export.

Tobacco Manufacturing. Plug tobacco, cigarettes and smoking tobaccos tend to be prepared by the use of much machinery in large factories near the centers of production. Cigar mak-

sorted to all these methods. For example, Peru maintains a government tobacco monopoly, the states of Brazil have imposed export taxes on tobacco, and Argentina collects considerable revenue from the import duties on tobacco and tobacco products. Venezuela and Guatemala maintain a government monopoly of the importation and printing of cigarette paper, which is sold to cigarette manufacturers, and thus collect a tax for revenue. The United States imposes duties on imports of raw and manufactured tobacco, and internal-revenue taxes on manufactured tobacco of all kinds; imported manufactured tobacco pays both the duties and the internal-revenue taxes.

The duties on tobacco in most countries are so high as practically to preclude the entry of competitive tobaccos. In general, only those types of tobacco which are not produced in a particular country are imported. High duties can be paid on such tobaccos, provided they are essential in the manufacture of certain tobacco products required by consumers.—U. S. Tariff Commission, *Foreign Trade of Latin America,* Part III, Report 146, 1942, p. 212.

ing, on the contrary, has long been a hand industry peculiarly dependent upon skilled labor. The trained cigar maker, using little besides nimble fingers and a sharp knife, rolls and shapes the filler, binder and wrapper into a fragrant Havana cigar. However, machines have succeeded in replacing this hand labor for a large part of the product.

. . . 19

The Animal Industries

1. Meat and the Meat Supply

Meat tastes good. It is a great substitute for good cookery, but he who says it is a necessity shows his ignorance—double ignorance, ignorance of the world and ignorance of the science of nutrition.[1] It must be added, however, that among the scientists working on human nutrition, the pendulum is now swinging somewhat toward meat again.

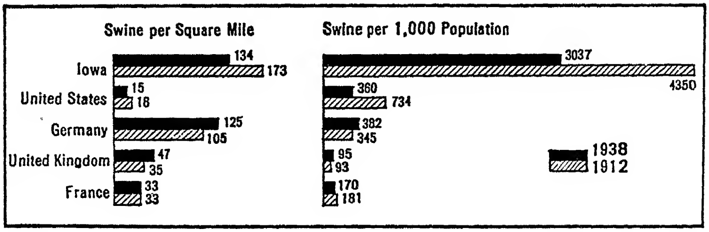
Among most peoples of the world it is not a matter of what the scientists say, but of how much meat can they get. Among most of the people of the world meat is something of a luxury and is becoming more so. That it is not a necessity is shown by the fact that hundreds of millions of people rarely eat it and many never do. Some are even forbidden by their religion to eat flesh and they live up to the prohibition. An examination of food values (Table 22) shows the sufficiency of vegetable foods, a fortunate fact, for many millions of the human race in Asia and Europe can rarely afford to eat meat because of their poverty.[2] It is a luxury possessed chiefly by the people of lands of sparse population, where for that reason meat is cheap. Man always has the choice of eating plant products directly or, if land is cheap and plant products abundant, he can feed them to animals and then eat the animals. The latter is much the more expensive form, for the making of a pound of meat requires the grass from much land or 5 to 10 pounds of grain, the equivalent of eight to fifteen 1-lb. loaves of bread. In densely peopled regions where there is not food enough for both man and beast, man eats the food and does without the beasts.

Relation of Meat Animals to the Density of Population. Japan in 1940 probably presented a most extreme example of a people with few animals. There was a population density of 488 people per square mile, and the rough and steep surface of the land permits but a sixth of the land to be cultivated. The apparent room for pasture does not exist because of a dense growth of bamboo grass wholly unfit for food and impossible to eradicate. The effect of this absence of pasture and pressure of population in limiting the production of

[1] Mr. Bernard Shaw, who says he is a vegetarian, put it thus when asked whether he thought an apple a day would keep a revolution away: "I have repeatedly commented on the characteristic ferocity of vegetarians. The bull rhinoceros, elephant and human vegetarian philanthropist are typical examples of dangerous animals undulled by corpse eating. Armies fed on barley have conquered half the world; clans fed on oatmeal or potatoes have had to be exterminated because of their incorrigible pugnacity. "Meat keeps people quiet, if they get enough of it. A week of beefsteak would change me into the mildest of men. Meat has not much value as a food, but it is incomparable as dope." (*New York Times,* October 24, 1924.)

A critic says that Mr. Shaw is cheating a little, since he is reported to take liver extract every day.

[2] Recent figures (in pounds) of prewar meat consumption per capita per year: Italians, 47; French, 94; Germans, 132; English, 136; Americans 145.



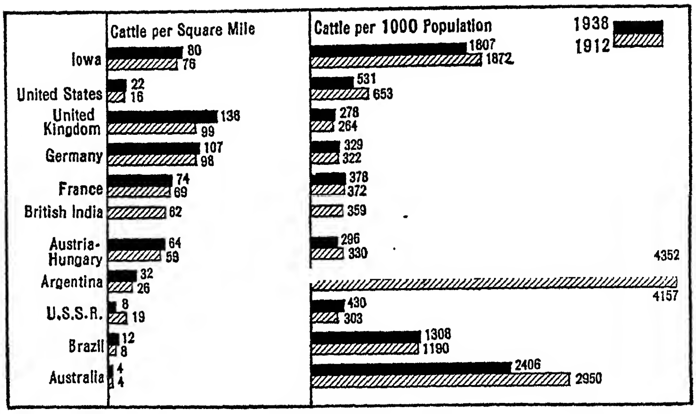
This comparison of the ratios of swine to land and swine to people probably contains surprises: for example, the small numbers for the square mile in the United States in comparison to the United Kingdom and Germany. The facts are, of course, that the United Kingdom and Germany are almost all good land, while we have about half of our country with rainfall insufficient for agriculture.

domestic animals is most marked. The Empire had over 71 millions of people, and of horses and cattle combined but 4.7% as many, while the number of sheep and hogs was but 1.6% of the number of people. Both of these figures are utterly insignificant in comparison even to those of Europe. For the United States the ratios were 58 and 77% respectively in 1939, 113 and 130% in 1911. The American trend is significant and will continue downward.

Denmark is an agricultural country where some meat is eaten and animal products are an important factor in commerce. This country, three-fourths of it in fields and pastures, has four times as much of its area suitable for farms as Japan, and has passed the limit in the number of animals it can support on native food, since cattle foods such as wheat bran, cottonseed meal, linseed oil cake, and other grain products are being imported in large and increasing quantities from the United States, Argentina, Russia, and European milling centers. The state of Iowa, practically all arable, a strictly agricultural state in the midst of the Corn Belt, is far better fitted than Denmark to support livestock; but it has far less horses and cattle per square mile (Iowa 93, Denmark 232). Iowa, on the other hand, with 45 persons per square mile to Denmark's 226, has 113 hogs and sheep while Denmark has 259. Iowa exports grain. Denmark imports it.

On each square mile of fertile and well-tilled Holland are 686 people, with cattle and horses 36% as numerous, and the sheep and swine 21%. Meat is imported into Holland, although the Dutchman eats less meat on the average than does the Englishman. Intensify agriculture as we may, dense populations inevitably find meat scarcer than do sparse populations.

Meat Animals in Sparsely Peopled Lands. By turning to a country with sparse population, the reverse of the above conditions is met—cheap and abundant supplies of meat for home use and a large surplus for export. In the United States the average population was about 45 to the square mile in 1942; the total numbers of the cattle and horses 64% (113% in 1911) of the population, the numbers of sheep and hogs 89% (130% in 1911). The high ratio of animals to men makes the United States a great exporter of meat products, but



The ratios of cattle to land and cattle to population show the results of percentage of good land, intensive agriculture and dense population. Note the towering positions of sparsely settled lands like Argentina and Australia. Argentina's meat export is explained. The United Kingdom stands high, perhaps surprisingly high, because the parts of it that are not good for farming are too wet for agriculture, which makes them prime pasture land.

the countries to which we send meat exceed us in the number of animals that they produce per square mile.

The inevitable decline in the ratio of meat animals to man (see Table 30) has

TABLE 30

Number of Meat Animals per 1,000 Population in United States

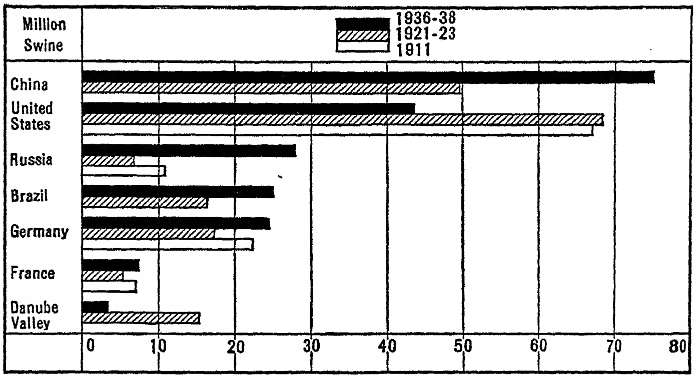
	1893	*1903*	*1913*	*1923*	*1933*	*1943*
Sheep.......	751	841	558	361	432	424
Hogs.......	733	617	665	618	506	560
Beef cattle..	571	587	391	397	572	601

raised the relative price of meat in the United States and has, according to some estimates, cut in half the per capita meat consumption in the United States since 1840. Most of the increase in prices has occurred since 1901. The figures do not entirely show the facts because the average size of the slaughtered hog has declined.[3]

2. *Swine*

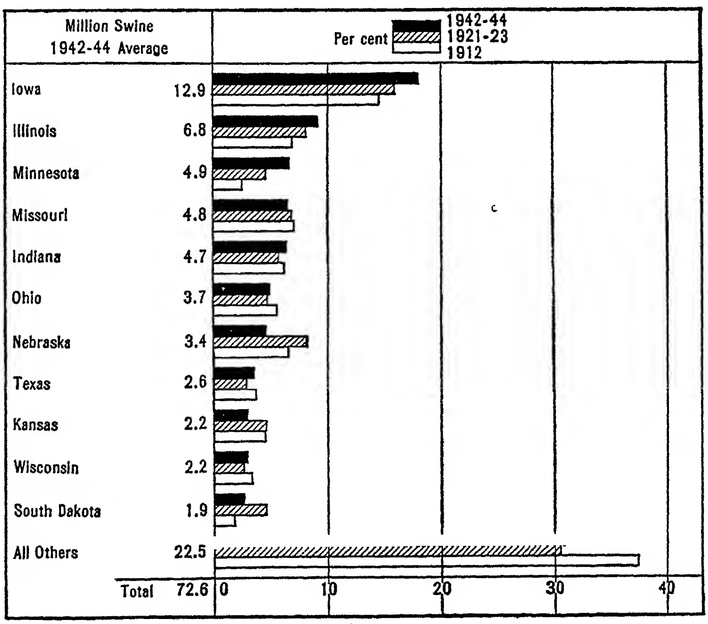
Qualities and Distribution of the Hog. Swine are meat animals of grain-growing lands, as the sheep is of grass-growing lands. Thus pastoral Australia has 97 sheep to one hog, and Iowa, a great corn state, has 58 hogs to one sheep. The hog was originally an animal of forest countries living upon acorns, nuts, roots, grubs, and other highly nutritious foods. Consequently, in domestication he must have somewhat similar foods, since his small stomach is not adapted to a complete diet of bulky grasses. In his original forest home he converted the abundance of autumn nuts into a layer of fat which covered his body and carried him through the hungry time of winter. Therefore, the rich grains of the farm

[3] If one wishes to illustrate this philosophy still further, see Argentina, Uruguay, Australia and New Zealand in the annual book of Agricultural Statistics, U. S. Dept. of Agric., Washington.



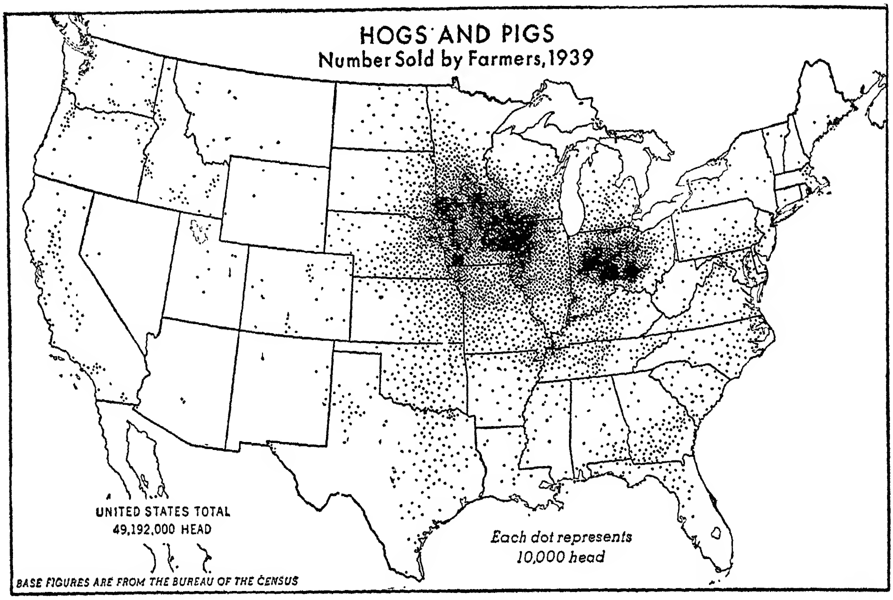
A

World distribution of swine by millions. It appears that Russia made a rapid recovery. The speed in the German recovery in 1921 shows the quick reproductive capacity of swine. Apparently the United States has passed its peak.



B

Distribution of swine in the United States, three-year averages by percentage for three periods, and by millions for the last period, shows the advance of the prime corn states of Iowa and Illinois, and the rising corn state of Minnesota, the static eastern Corn Belt, the decline in the drier west—Nebraska and Kansas.



This map of commercial hog production shows its close relation to the Corn Belt, except the areas near to Chicago, which is a grain export region, due to the ease of getting the heavy product to the Chicago market.

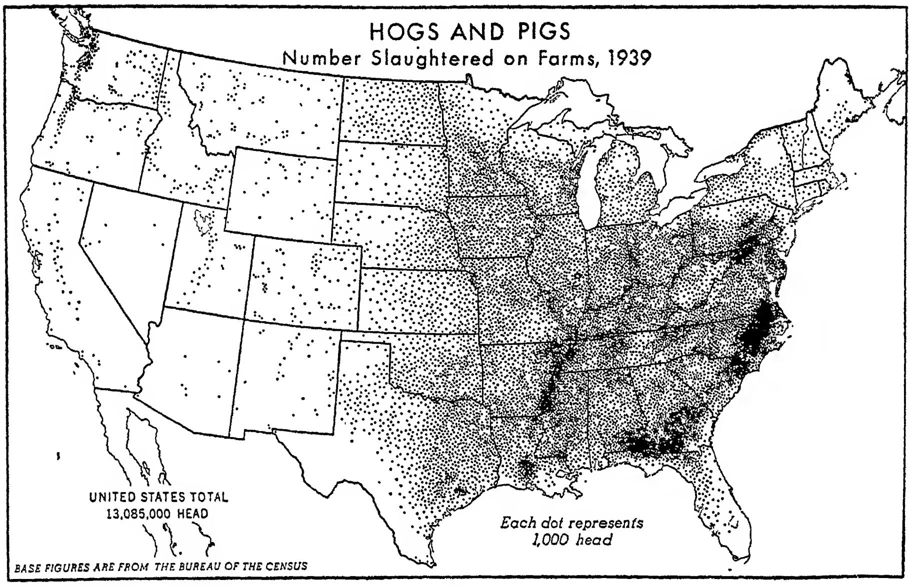
suit him exactly. He is still fond of the nuts and acorns of his original forest home, but is able to eat anything from a piece of meat or garbage to the weeds which his owner pulls from the garden. This catholicity of diet may partly explain a higher meat yield for food consumed than is given by our other farm animals. Tame, harmless, hardy, and fecund,[4] the hog is an admirable dooryard scavenger and meat producer for the cottagers of many lands, and has attained an almost worldwide distribution, being of great local importance as a food supply in many countries where he is of no commercial value. He is the friend of the Irish and Russian peasant and of the new settler in British Columbia. He lives around the shack of the half-breed Indian of Mexico and South America, and is as friendly to the Spanish and Italian immigrant in the Argentine as he was around the stone house in the old countries of Europe. He is as much at home beneath the shack of the Negro in the West Indies as by the palm leaf hut on the banks of the Congo or the coast of Guinea. In the eastern world he is common in China, Malaysia, Australasia, and the mid-Pacific, where, in at least one group of coral islands, the price of a dusky bride is from ten to twenty pigs.[5]

[4] It is a rare flock of sheep that increases 100% per year, while tenfold increase or more of swine is common. All these habits and abilities combine to explain the fitness of the hog as the meat animal par excellence of the lands of garden agriculture.

[5] American flyers lost from a wrecked airplane (1945) in the wild interior jungle of New Guinea beyond any possibility of travel, except by airplane, report as follows:

"Our money and trinkets meant less than nothing to them [the natives]. They wouldn't accept any of our equipment or touch our food. . . .

"So the Army dropped us a bag of assorted shells. They proved magic. Just what the natives



This map shows the wide distribution of hog production and its importance as a source of the local food supply. The rural families revel in fresh pork for some weeks after the annual slaughtering festival of early winter.

Hogs That Range in Forests. In many parts of the United States it is customary to let the hogs run in the forest where the fallen mast provides a large part of their food. This occurs in the Appalachian Highlands, in the Ozarks of Missouri and Arkansas, and in many parts of the South Atlantic and Gulf States. Great injury to the southern pine forests often results from the up-rooting of the young pine which the hog kills by eating the succulent tap root. The excavating abilities of this pine rooter, a long-nosed beast called "razor back," are an athletic marvel excelled only by his speed. In the southern states, salt pork, easily kept in a warm climate, is the staple meat food of the working man, white and black alike.

Hogs fatten in many south and central European forests. An important hog-raising district is located in southwestern Germany, where the animals can roam the beech forests and fatten on the beech nuts. In Yugoslavia, hogs, largely mast fed, are one of the most important exports in normal times. The fertile valleys of this mountainous country are carefully farmed chiefly for grain, but in the oak and beech forests of the mountains there is excellent feeding ground for hogs, which are sent to

wanted.

". . . Fifteen shells bought a pig. Five purchased a stone hatchet, a much coveted souvenir by which we hoped to persuade our friends that we had really been places.

"The sergeants were already in possession of seven pigs by the time we arrived in the big valley. One was a runt, cute as a button. The boys named it Peggy in honor of me. Peggy must have thought she was a dog.

"She followed everyone around and the moment any of us sat down, climbed on our laps. The paratroopers scrubbed Peggy every day until she shone. We never could bear to eat Peggy." (WAC Corp. Margaret Hastings, "Shangri-La Diary," *Washington Post,* August 6, 1945.)

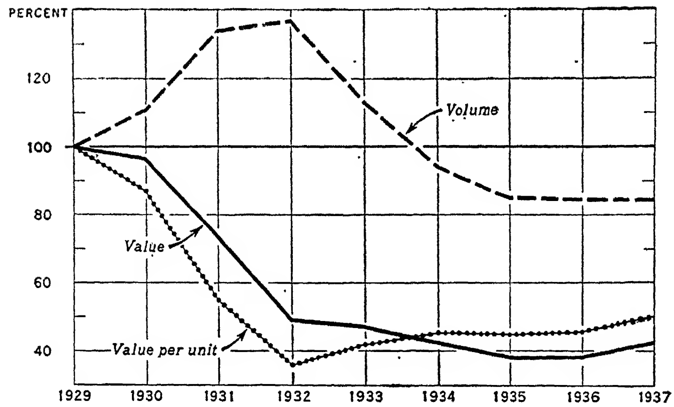
Budapest, Vienna and Germany. But the mast-fed hog is of relatively small importance in comparison to the grain-fed hog. The growing of mast as a science has not yet received any serious effort. It has great possibilities in the long future if we can continue to apply science.

Sows and pigs pasturing on oats, which are in the grass stage in March at the Auburn, Alabama, Experiment Station.

Young man, go South—if you would raise hogs! With this system of growing crops for the hogs to harvest, pork can be produced more cheaply in large areas of the Cotton Belt than in the Corn Belt and it is being done to some extent. The ten months' growing season is an important factor.

Relation of the Hog Industry to Grain Growing. Since the hog must have some kind of concentrated food such as acorns, nuts or grain, he is a natural product of the regions producing cheap grains. The chief regions producing hogs for export, therefore, are those in which corn or barley abound. Since corn has long been the cheapest and also the most fattening of the grains, and since corn is much more important than barley for hog feed, the Corn Belt of the United States has a greater relative advantage than any other large area for the production of those cheapest of animal foods, pork and lard.[6] The Corn Belt is the leading hog, pork and lard exporting region of the whole world. The farmer in Iowa, Kansas or Nebraska nearly always grows one or two fields of corn, and often keeps from 20 to 100 hogs, which he feeds almost entirely upon the corn. Hog is condensed corn, and nearly a half of the American corn crop goes to the market in the form of pork. Owing to the great ability of this grain to produce fat, the American hog is often called the "lard hog," because of the large amount of lard (melted fat) he makes. He is quite different from the so-called "bacon hog" of the barley-growing districts of Canada and Europe. Owing to the fact that barley yields less grain and therefore costs more to produce than corn, the pork raisers of Canada and Europe feed their pigs as much as possible on grass, especially clover. This food, rich in protein, produces more lean meat in the pig's body than does the corn diet, and the famed Danish or Irish bacon with its streaks of lean with the fat is the favorite on the English breakfast table. While Danish bacon on the British market in 1924 was selling at 22 to 24 cents, and Canadian at 17 to 21, the fatter American bacon was bringing only 14 to 17. (U. S.

[6] The United States Department of Agriculture states that it takes about 6 pounds of grain and 6 pounds of hay to produce a pound of lamb (live weight), 10 pounds of hay and 10 pounds of corn to make a pound of beef, and 5.6 pounds of corn or its equivalent for a pound of pork. Steers and sheep also dress from 40 to 65% when butchered (average 55%), while the waste of a hog carcass is only 25%, and sheep 53%.



World exports of bacon, 1929 to 1937, volume and gold value. Index, 1929 equals 100. Here is a record of double industrial tragedy. Unemployment in cities of the western world drove prices down to the bankruptcy level in farming countries. We can say this under the bacon graph because all the grains and grain products tend to go together in price.

Commerce Reports, August 25, 1924.) Behold the results:

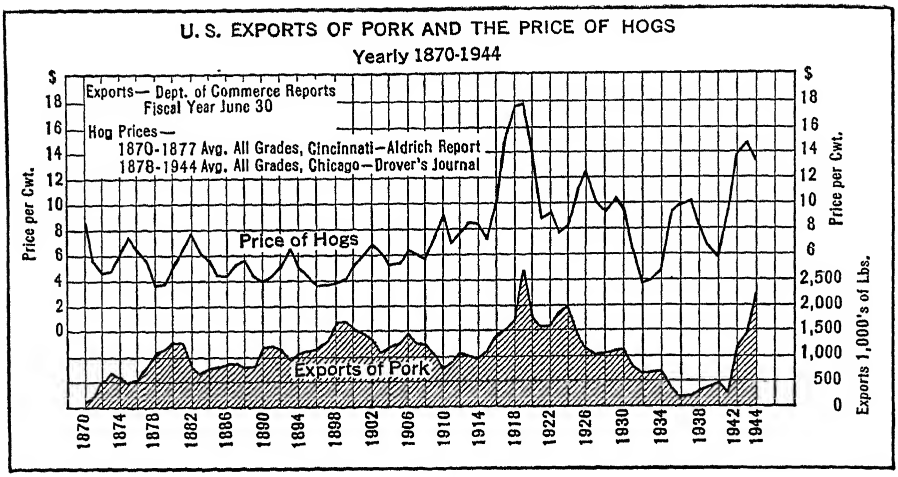
British Imports of Bacon in Hundredweight

	1923	*1934*	*1937*
United States.....	2,828	39	6
Canada...........	834	894	1,387
Denmark.........	3,530	4,287	3,429
Irish Free State...	308	368	510

Because of this desired leanness, some European and Canadian bacon is imported into the United States, although we have several millions more hogs than any other country except the U.S.S.R. and China, and send vast quantities of cheaper pork to Canada, United Kingdom, Ireland, and France. At the same time that Ireland imports American pork, it produces bacon of high quality, which is exported to the English market. The most important center of European hog production, however, is the barley region adjacent to the Baltic Sea in Germany, Poland and Russia. In China, with what may be called its ultimate agriculture, we see the agricultural triumph of the pig, the most efficient of meat producers. The tiny farm that cannot consider a sheep, cow or donkey, has one pig as a kind of animated, productive, edible garbage can.

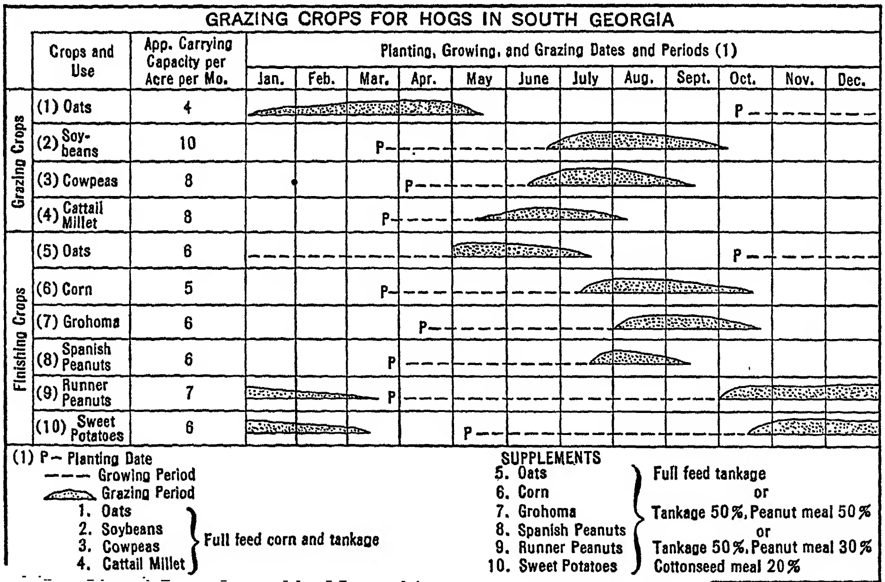
3. *Distribution of Cattle*

Wherever there are wide spaces of untilled grass lands we are likely to find cattle, especially if the pasture is good rather than poor. They were pioneers during the nineteenth century upon the vast plains that the white man won from the wild animals and natives in North America, South America, Australia, and central Asia. On account of their size, strength, and speed, they can combat dangers, or, if necessary, flee from them. They are tough and healthy beasts. Their ability to withstand heat



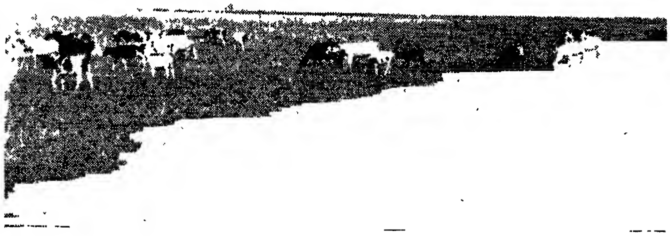
A

Export price is shown in dollars per hundredweight at the left, quantities of export at the right. Prior to 1915, declining price almost universally resulted in increase of exports, which served to level off price fluctuation. In 1919 the United States Government gave away pork to prevent starvation in Europe, and therefore the high prices and great exports went together. Supply and demand took charge again until World War II and the low export figures of the 1930's are due in a large part to lowered supply resulting from artificial restriction of production.



B

This chart from a South Georgia Experiment Station shows the time of planting and pasturing of various crops which the hogs will harvest, also the time and relative amount of forage produced by each crop. Note that even in mid-winter the pig can graze the tops of young oats and can root up peanuts and sweet potatoes that grew the season before. The lower right has recommendations for farmers as to what supplementary food they should give to complete the fattening ration of the animals. This chart is the visual basis of the recommendation, "Go South, young man, if you would grow hogs."



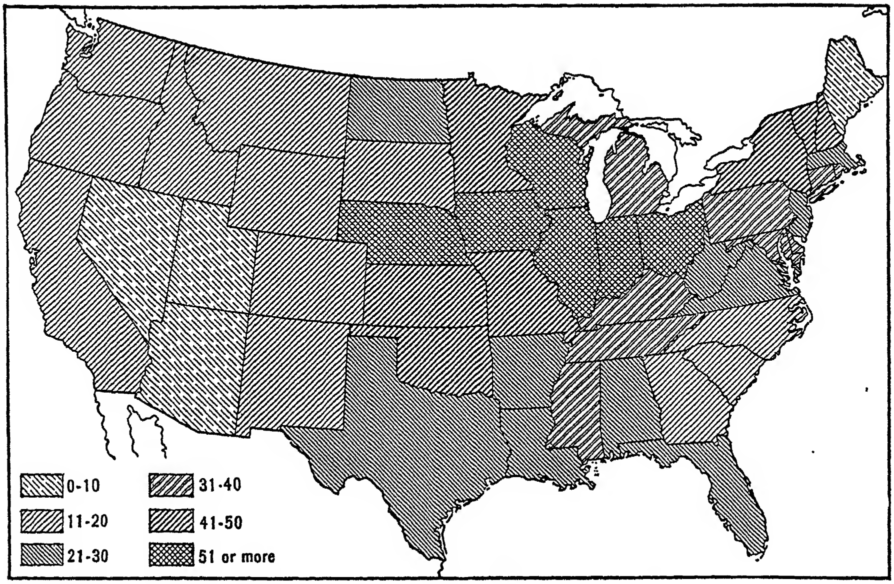
The Great Open Spaces. Such a pasturing scene on the flat plain might be in any one of five continents. It happens to be on the Great Plains of the United States, northwestern Colorado. Note the flat treeless skyline with the slight speck at left center, which is a farmhouse.

and moisture has enabled them to go into lower latitudes than sheep. With the exception of the humid plains of the Amazon and central Africa and a few places in the Oriental tropics, they are to be found from the Straits of Magellan to Hudson Bay in the Americas, and from Tasmania to Kamchatka and North Cape in the Old World.

In the first stage of the occupation of new plains, before transportation has been well developed, the only export products cattle can furnish are the non-perishable hides and tallow. A century ago the half-breed Indians on the plains of the Argentine were producing these commodities at the same time that the American Indians and frontiersmen were skinning buffalo for their hides upon the great American Plains reaching from southern Texas to Lake Winnipeg and beyond. This vast plain was a splendid pasture and had been occupied by the buffalo, a close relative of the ox, for an unknown period of time. They wintered in the warm lands from Oklahoma to Mexico and each spring went north across what is now northern Texas, western Oklahoma, Kansas, Nebraska, Dakota and on into Canada. With the approach of winter they migrated south, the herds often covering the plains for miles in such great numbers that they actually stopped the progress of trains when the first railroad was built across the plains from Omaha in 1868. In the next four years, many millions of buffalo were slain for sport or for their skins, and now this great animal is practically extinct,[7] except for a few herds in National Parks, private reserves, and zoological gardens. His place was promptly taken by the long-horned Texas cattle which had run wild with him for three centuries since their ancestors had got away from the early Spanish settlers. In living with the buffalo on the plains they had become well adjusted to the conditions of the life. Their long horns were admirable defense against wolves and bears, their long legs and muscular bodies were efficient in flight. But the animal himself was not very good for beef and so he has been improved (and eliminated) by crossing with better breeds brought from England.

The earlier part of this chapter

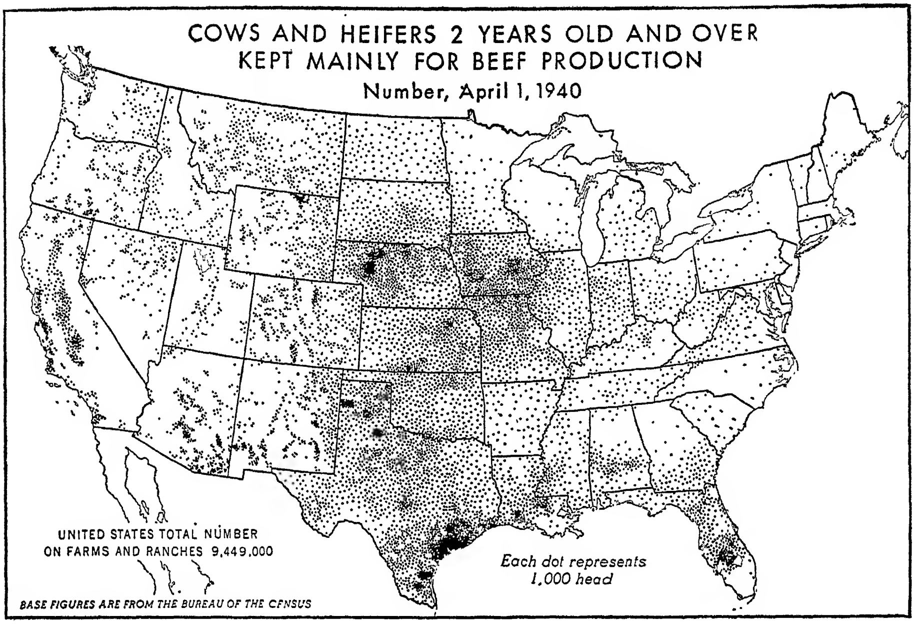
[7] A small wild herd, now called the Woods Buffalo, is reported to have fled this slaughter by taking refuge in the forests near Great Slave Lake. Zoologists are already reporting change of form.



In explaining this map of density of cattle and calves per square mile, you have a good chance to test your knowledge of agricultural geography.

showed, however, that cattle reach their greatest density in areas of comparatively dense population.

Cattle on the Great Plains of North America. The great open plain west of the one hundredth meridian was too dry for good farming; therefore the pioneer farmer could not take it, as he had taken up all Iowa and the eastern parts of Kansas and Nebraska. The United States Government, to which the land belonged, would not sell it, for fear of great estates and land monopolies. Although it was excellent pasture for a few cattle per square mile, no one could afford to take it even as a gift, under the homestead law which gave 160 acres to each settler, but limited his acquisitions to that amount. In a land fit only for scanty pasture, a man needs hundreds of acres. So this vast area of the plains, larger than any European country except Russia, remained every man's land, as the government would not sell it and people could not take it as a farm homestead. People branded their cattle, turned them out upon the plain in great numbers, and then, after an annual round-up when all the cattle in a large area were brought together, each man took the cattle that had his brand and sold them. This was a very cheap way to raise cattle and very profitable for the cattle companies. It made cheap beef for market and, along with the settlement of new cowlands west of the Missouri River, it led to a large number of animals per capita as shown in Table 30. The freedom of the range naturally led to an overstocking. The grass, especially in periods of drought, was eaten so close that it could not produce seed, and in many places it died out so that the plains do not now support so many cattle as they once did and are being greatly injured by both



Compare this map with the density of population and observe how beef cattle and human beings appear not to mix. Notice especially the great dairy states—Wisconsin, Minnesota, New York, Pennsylvania.

wind and water erosion and by the advance of inedible weeds. A belated grazing act now attempts to remedy this.

Among the other changes now taking place in cattle-ranching methods of the West are the passing of much land into private ownership and the fencing off of the free range by processes that might be called legal fraud. Many of the huge ranches which contained thousands of acres are being cut up into smaller units and drought-resistant forage crops now supplement pasture cattle raising. The industry is becoming more careful and scientific.

The Migration of Beef Cattle. The range cattle spend one or two years upon their native range, living chiefly or entirely on grass, and are then shipped into the Corn Belt where the farmers keep them for a few months, fattening them on corn before sending them off to the great markets for slaughter. To some extent, these cattle are fattened in the farms of Pennsylvania and other eastern states, as many as 60,000 to 80,000 a year being distributed at the city of Lancaster, Pa., among the fertile and well-cared-for farms of that district. To a smaller extent this same emigration is repeated in the Southern Highlands. In the hilly country of southwestern Virginia, northeastern Tennessee, and West Virginia, there is a section of good grass country where young cattle are raised and sent to the farm lands of the Great Valley and the Piedmont sections of Virginia and Maryland for fattening.

Importance of Cattle on Arid Lands with Some Irrigation. Irrigation in the West is important to the cattle industry.

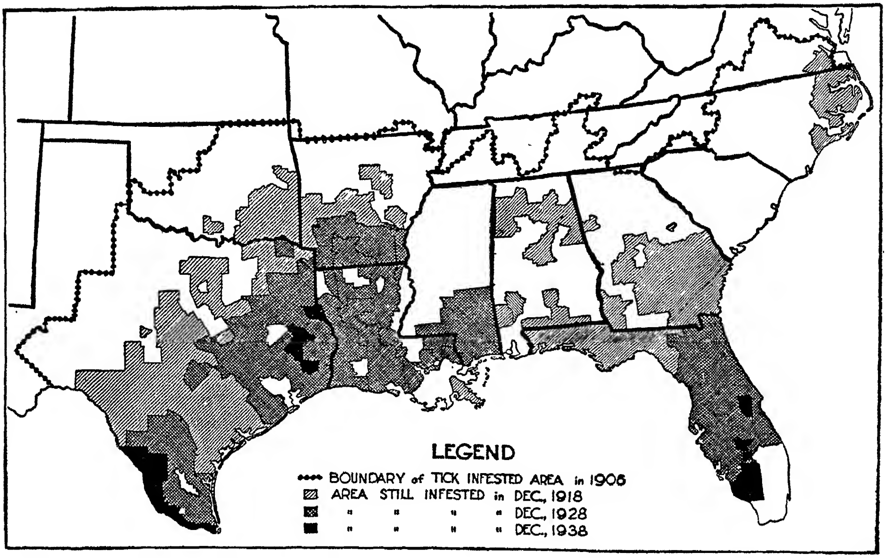
A

In the background, pastures on a treeless hill. In the center, cottonwoods by the river, and haystacks from irrigated alfalfa. In the valley foreground, some cattle at pasture. This might be New Mexico, Colorado, Wyoming, Montana, Idaho, Oregon, Alberta, Argentina, Turkestan, or Anatolia. It *is* in the western United States.

B

This feed lot is a characteristic part of the valley equipment of the lands shown in the previous figure.

Indeed, beef is the chief commodity produced on most of the irrigated districts of the United States. Alfalfa leads all other irrigated crops in the area under cultivation. This plant is the richest of all the clovers. It sends its roots to great depths in the ground and when the moisture supply is abundant it yields heavy crops of hay, in from one to ten cuttings a year according to climate. Fortunately, the irrigable valleys are widely scattered throughout the cattle range from Canada to Mexico, from western Kansas to Oregon, so that these favorable alfalfa fields are really scattered oases in the scanty and semi-arid



This map shows how effective was the quarantine for tick fever of cattle between 1906 and 1938. Ticks sucking blood from cattle get germs in the blood and biting another animal, transmit the diseases exactly as the mosquitoes transmit malaria and yellow fever. Before this discovery, the outbreaks of Texas fever in the North Central States after arrival of southern cattle caused prohibition of cattle shipment to the North during the tick season.

Dipping the cattle completely under a bath of disinfecting liquid removes ticks. This map shows the advance of the tick-free area—a great boon to possible cattle production in the South. This application of scientific knowledge is a fine example of the new science which unfortunately could only be effective with the aid of rigorous law enforcement. It did not happen to suit some people to dip their cattle; they didn't believe in ticks, therefore they had to be coerced.

pastures. During winter and the seasons of drought, alfalfa hay supplies the cattle from the ranges with abundant food and fattens them for market (see Fig. 596).

Cattle in Southern States. The southern states have great cattle-producing possibilities. The Minnesota farmer must build large barns to protect his animals and their food from the cold and storms of winter. He must feed his animals full half the year from the results of his summer's toil. In Alabama there is so little winter that a barn is scarcely necessary and the growing season is so much longer that more forage can be produced on a given piece of land than in the northern states. The cattle can also pasture nearly all the year, thus making the industry require less capital and labor than in the North. The great advantages of the South for stock raising were for many years practically unused, because of the ravages of the cattle tick, and because of the almost exclusive dependence of the farmers on cotton, a money crop of unusual excellence. The ravages of the cotton boll weevil have had the effect of recently turning the cotton planter's attention to high-grade beef cattle as a new money crop.[8]

[8] The breaking up of the one-crop system of cotton production by the Mexican boll weevil has done more to force an interest in cattle production in the South than anything else. In one place,

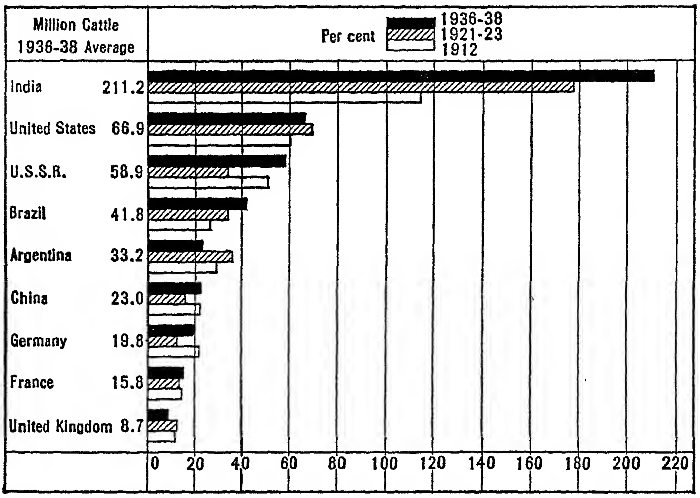
The Shipment of Live Animals. During the past three-quarters of a century there have been great improvements in the handling and marketing of meat. Formerly live cattle were carried in trains from Kansas to Chicago, and on to New York and Boston for slaughtering to supply the eastern market. About 1874 we began to ship live cattle to Europe. It is, however, much more expensive to transport live animals than slaughtered ones, because the live animals occupy more space than dead ones, some die on the way, all must be fed, and they always lose weight.

The Effect of Improved Methods of Shipping and Preserving Meat. The invention of artificial refrigeration has done much to make possible the slaughtering of animals nearer the place where they are raised. About 1875 the refrigerator car made it possible to send dressed beef from Chicago to Boston more cheaply than the live animals could be sent. In 1879 came a sure method of hermetically sealing meat in cans so that it would keep for a long period, thus giving another force to locate the slaughtering industry at the great cattle markets. Attempts, however, to operate packing plants upon the great plains where the cattle themselves are produced have resulted in failure. This is due to the lack of a market for many of the by-products and less desirable kinds of meat which the varied market of a large city will consume. Consequently, packing plants are located in the city nearest to the places where the cattle are fattened. Cincinnati and Chicago were the first packing-house centers, but St. Louis, Omaha, Kansas City, and Minneapolis have now become great centers. Plants have been established also at Fort Worth in northern Texas and in smaller cities on the western fringe of the cornlands, but Chicago is yet, as it has long been, the greatest meat-packing center in the world.[9]

The modern meat-packing plant handles cattle, hogs or sheep, according to the demands of the market, and is one of the most wonderful examples existing of speed, mechanical perfection, and the use of by-products. A procession of live animals goes through a gate and in a few minutes their lifeless bodies are hanging on a little trolley on which they travel past a long row of men, each of whom has his perfectly definite work to do. In a surprisingly short time every particle of the animal has been taken for its particular use, and the chief part of the carcass rolls into the cold storage room. So perfect is the utilization of the refuse that absolutely nothing is wasted, and the phonograph has even recorded the pig's last squeal. Bones are made into knife handles and buttons, small pieces and chippings are ground for fertilizer; the hair goes for mattresses and plastering; the intestines for sausage casings; the hoofs are made into gelatine and glue. Even the blood is used for buttons and other industrial purposes, the total number of inedible products being over 100. Grease, not fit for culinary use, is made into soap. All other parts, not otherwise used, go for

possibly two, this blessing has been recognized in the semi-ludicrous form of monuments to the weevil—real monuments of masonry and genuine bronze.

[9] The first 9 centers in the order of importance: Chicago, Ill., E. St. Louis, Ill., Omaha, Neb., So. St. Paul, Minn., Kansas City, Mo., New York, N. Y., Sioux City, Ia., Fort Worth, Tex., Los Angeles, Calif. New York is in this list because of the local demand for kosher meat.



Cattle in nine leading countries, by percentages, 1912 and two three-year periods, by numbers in the last period. Perhaps the position of India will be a surprise to most people. It is very suggestive that while the United States has declined a little in its share, Russia has gained some and India has gained greatly. Most of these are work animals and their increase in number has accompanied the alarming increase in the Indian population which is discussed in the last chapter of this book. If a college student lives out his expectancy, he will surely read of famines in India, unless the censorship . . .

European method. It was formerly a heavy beef exporter, but now specializing in dairy products as befits the more intensive agriculture. There is heavy import of feedstuffs, mostly grain. The upland pastures of southwestern Germany and the mountain pastures of the Alps are also famed for their cattle. Except where land is too rough for tillage, most of the cattle of western Europe live in barns most of the time and have their food brought to them, because by this means the arable ground can be kept in the cultivated crops which are more productive than pastures. In a day's journey across prewar Germany one saw no cattle at pasture unless in a field unsuited to the plow. This carrying of food to the cattle is the explanation of the large number of cattle per square mile. There is a compromise practice. Tie the cows, a row of them, to stakes. When the grass is cleaned off around the stakes, move the stakes.

Table 31 merits thoughtful examination.

TABLE 31

CATTLE PER CAPITA

United States	0.54
Argentina	2.53
Australia	2.06
Canada	0.82
Cuba	1.11
Denmark	0.83
France	0.37
United Kingdom	0.27
Netherlands	0.32
New Zealand	2.75
Norway	0.48
Spain	0.17
South Africa	1.09
Sweden	0.47
Switzerland	0.38

Source: Agricultural Statistics, 1943.

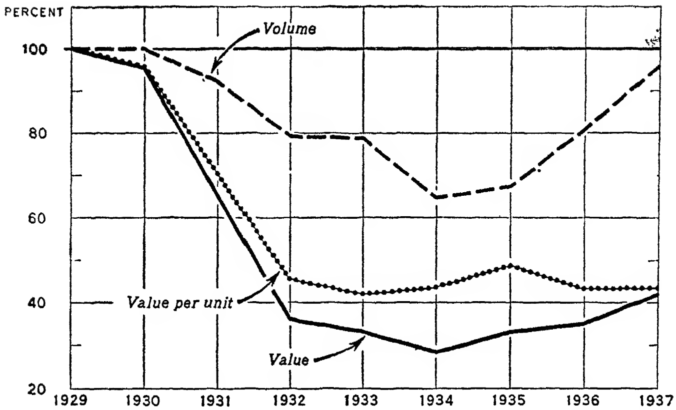
The Soviet Union had about as many cattle as the United States in 1938. Russia has a vast area located between northern forests and the desert that begins near the Caspian Sea. In normal times she has been a beef exporter to western Europe.

Cattle in the Old World Arid Belt. The dry summers of the Mediterranean climate do not produce good pasture, so that in those countries cattle are not so important as in north Europe. Here the ox is a work beast, and the goat and sheep function as milk animals. Cattle are widely distributed in the Eurasian arid region and are to be found in limited numbers from Spain to Palestine, Persia, Turkestan, and Mongolia. In the last province the scanty pastures furnish the principal exports of the inhabitants. These lands of little rain find their closest counterpart in the American ranges between the Sierras and the Rockies.

The Cattle Industry of the South Temperate Zone. The refrigerator ship, refrigerator car, and the cold-storage plant have made possible the carriage of meat to market halfway around the world, so that the ranchers of the south temperate zone need no longer keep cattle merely for their hides and tallow. Prosperity has resulted for Argentina, New Zealand, and Australia—countries so admirably adapted to pastoral industries. Packing plants like those of Chicago and Omaha now stand at Wellington, New Zealand; at Sidney, Brisbane, and other places in Australia; at Buenos Aires and Rosario, in Argentina; and at Paysandú, on the Uruguay River in Uruguay. From these plants, the frozen carcasses of cattle and sheep are wheeled by the thousands into the freezing chambers of the ships which carry them across the entire torrid zone to deliver them, still frozen, at the cold storage warehouses of Liverpool, London, Glasgow, Lisbon, Barcelona, Genoa, or Oslo. Here they are distributed to the butchers' carts of a hundred towns. This means cheaper food to the European and better prices to the farmer of the south temperate zone, but it has not sufficed to keep down the price of meat.

The high price for meat makes marked industrial changes. The Argentineans now pay tremendous prices (at times over $10,000 per animal) for prize-winning breeding stock of the English cattle shows and turn them out to increase on the fine level estancias (ranches) and fatten on the alfalfa which is becoming so important a crop in that country. Alfalfa has proved to be especially adapted to large areas and its use is spreading rapidly. It more than doubles the number of cattle that the land will support and lets the animal be slaughtered one year earlier than if fed native grasses. The open winter of Argentina, as of Texas, makes cattle ranching easy because barn building is unnecessary.

Before the invention of refrigeration the cattle industry of the Rio de la Plata countries had advanced beyond the shipments of hides, tallow, and bones, by the manufacture and export of tasajo and beef extract. Tasajo is a peculiarly well-preserved kind of dried beef cured in the sunshine of the great pasture plains (pampas). It has the quality of keeping indefinitely in such hot humid climates as Cuba and Brazil, so that transportation becomes easy and for many years it has had a wide



World exports of beef and veal, 1929 to 1937, by volume and gold value. Index number 1929 equals 100. The person who has read this book up to this point will recognize this as a member of a family of graphs, showing the calamity that hit export agriculture with the great depression following 1930. Note especially that in 1937 volume went up and prices stayed down.

distribution over tropic America. This same ease of transport also makes possible the production of tasajo in remote corners. Thus the growth of the frozen meat business in Argentina and Uruguay has sent the tasajo business upstream to Paraguay and to interior and southern Brazil.

Beef extract is a convenient means of putting a big roast in a small bottle, the manufacture of it therefore being an industry that could go to the farthest corner of the globe to find cheap beef. Almost every drug store in the world keeps a well-known brand of beef extract that has for some decades been manufactured on the banks of the lower Paraná from the cheap beef of Uruguay and Argentina.

American meat-packing firms from Chicago have opened branches in Argentina, Uruguay, Paraguay and Brazil, using American machinery and technique, and now compete with the meat extract manufacturers in the purchase of fat cattle and sell the meat in Europe in competition with the product of American farms. In 1939, Argentina supplied a half of the world's export of fresh beef and more than half of the canned beef. The cattle herd, estimated at 13 million in 1875, became 34 million by 1938. The present objective of the Argentine cattlemen is to produce nothing but baby beef for export—killing the steers as two-year-olds, when they should yield from 650 to 800 pounds of succulent meat. The United Kingdom provides the chief foreign market for this meat. Occasionally it comes to the United States.

Tropical Climate and Cattle. It has long been known that cattle did not do as well in the tropics as in the temperate latitudes, and scientific research is now giving the reasons.

1. Common cattle of America and Europe are incapable of sweating, and in hot weather they therefore actually get a fever temperature.

2. Many species of troublesome insects bring a number of diseases.

3. Vegetation that grows in such heat as Panama shows marked deficiency of vitamins when compared to products of similar species grown in the United States.

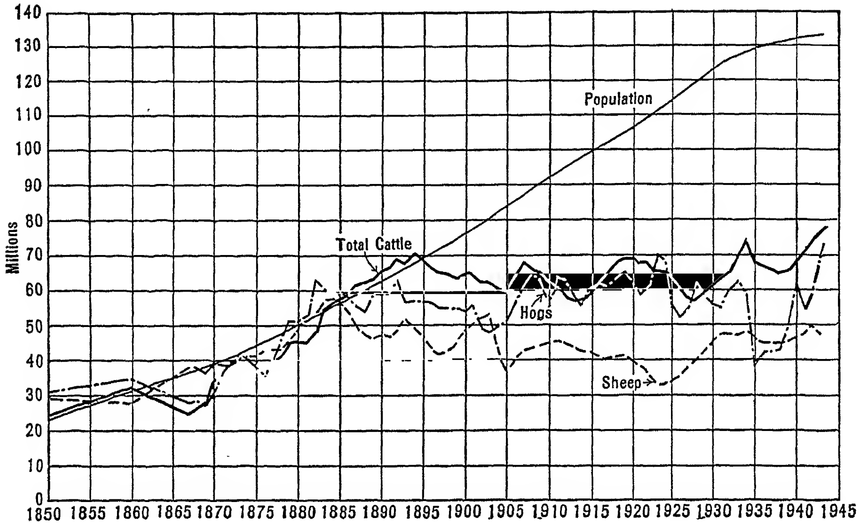
4. The heavy rainfall of many tropic localities has so leached the soil that the grass has marked deficiencies of necessary minerals, especially phosphorus. These deficiencies retard development and lay the cattle open to disease in many tropical countries and some parts of the southern United States.

5. The coarse tropical grasses have little protein—the grass of Dakota has more nutriment than that of the Cotton Belt.

Cattle in Tropical America. The cattle of American countries north of Argentina and south of the United States have little to do with international trade, but they are important locally. The people in the highlands of Mexico and Central America and the Andean countries of Colombia, Ecuador, Peru, and Bolivia have not the facilities to export meat even if they had a surplus of cattle, which they do not now possess. Cattle in large numbers are produced in small herds and consumed in all of these countries. Their hides, however, are a general and important export, since they keep indefinitely and can stand nearly all conceivable abuses in transportation. During the high price boom of World War I new meat-packing plants were built in Paraguay, and at São Paulo and other places in southern Brazil. The modernization and extension of the industry made great progress. Much of it was stopped, and some of the plants were closed by the price slump of the 1920's that so depressed the United States farmer. Plainly higher price levels can bring out more meat, as was shown by the increase in production in the United States during World War II. The vast ranges of the almost roadless interior of Brazil have huge cattle ranches on the open-range and round-up system. They send lean cattle to the cornlands near Rio and São Paulo, and at times there is an export. These cattle are of quality inferior to those of Argentina.

Cattle Raising in Africa. It is not commercially important at the present time. The climate in large parts is ill-adapted for it. In humid equatorial Africa, such as the Congo Basin, the climate is too wet and hot for the white man to live comfortably and the tse-tse fly is fatal to cattle over a large area. Aridity makes much of both north and south Africa resemble the least favorable parts of our own arid West. In between the tropical forest belt and the deserts, however, are belts of grassland where grazing is the favored occupation, and the scattered natives measure their wealth in herds of long-horned cattle. These African grasslands, sometimes called savannahs, which are found in a great horseshoe around the equatorial forests from Sudan to Rhodesia form a reserve cattle pasture for the high-priced future if they are not destroyed by erosion, induced by the white man's intrusion.

The Union of South Africa, in spite of its aridity, is at present the most important cattle-raising country on the African continent. The scanty rainfall of the veldt favors grazing rather than grain-farming and South Africa has about as many cattle (12 million) as Texas, Oklahoma and Nebraska com-



Millions of meat animals and millions of people in the United States, 1880 to 1944. Note the similarity of trend from 1855 to 1895, and then the divergence. There was very little first-class new land settled after 1900, and this graph shows clearly why 1900 marks the beginning of the rise in prices of meat and farm land in the United States. "The scarcity of a thing makes it high."

bined. There is a vast area of range resembling southwestern United States. The Dominion Government encourages the importation of better breeding stock and helps to fight diseases.

Cattle in Asia. India leads the world in cattle, but not in meat production. She has, for instance, more than three times as many cattle as the United States. The latter is second, then Soviet Russia[10] (almost as many as the United States), then Brazil, and only then Argentina. India has five times as many as Brazil, the fourth country in cattle! But in some sections of Asia they are used only as work animals because of religious aversion to meat-eating.

Asia is not likely to furnish the other continents any great amount of meat although her hide export is important. China has 20 million cattle (estimated), but she should eat them at home. In southeastern Asia, Siam, Indo-China and the Philippines there is about the same possibility of meat export as from Venezuela. The land is there but it needs energy like that of the Yankee or North European to fight disease and produce better meat animals. The tropics and our own South have possibility of meat, and perhaps milk, increase by breeding from the Indian Zebu—an animal that can sweat and also cross with common cattle; a promising new crossbred beef breed named Santa Gertrudis has already been produced in Texas.

4. *The Future Supply and Price of Meat*

The nineteenth century was a period of industrial discovery and commercial

[10] We should not forget that Russian cattle are (perhaps) chiefly in Europe.

expansion by means of railways, steamboats, refrigerator cars, ships, and scientific production. This permitted the western world to have for a few decades the cheapest meat supply we are ever likely to have.[11] There are no more great plains to discover, and the population is increasing much faster than the numbers of meat animals; and as a result meat has risen sharply in price in practically all parts of the world since the close of the free land epoch in the United States, about 1900 A.D. For this there is no remedy in sight, and it may not be an entirely fanciful prediction that fifty years hence a juicy beefsteak will be the centerpiece at the banquet table.

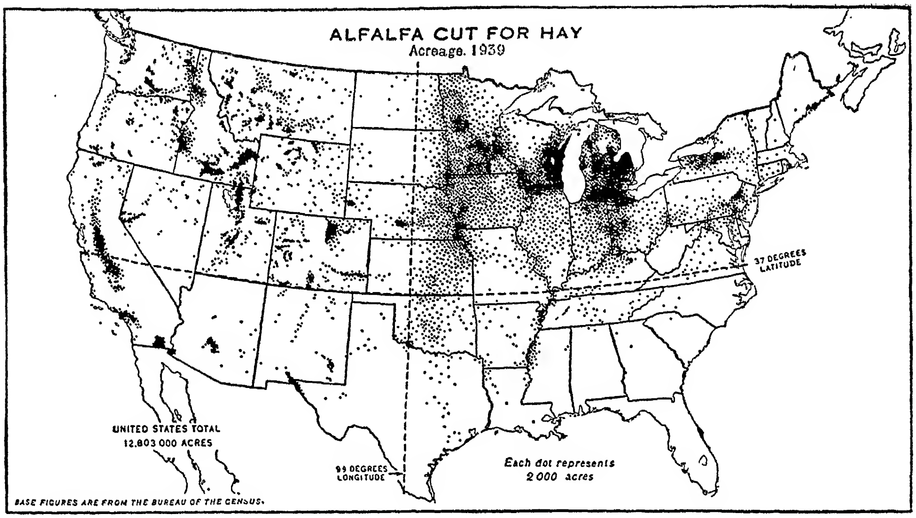
5. *Hay*

Relation of Hay to the Animal Industries. "All flesh is grass," says the Old Testament. Grass is the natural food of most of our domesticated quadrupeds. Pastures or grass fields where animals can feed in summer are the commonest feature of American farms. Hay, the dry grass kept over in barns or stacks for winter use, is almost equally common. In the harvesting of this crop we see one of the direct results of intermittent climate which stops growth. It is not necessary to make hay in lands where grass will grow the year round, as it does in parts of the torrid zone. Hay is usually a supply crop, to be eaten by the animals of the farm and become saleable in the form of work, meat, butter, cheese, milk, wool, hides or live animals. Practically all of the pasturing animals except the reindeer can get along well on hay. It is relished at the zoo alike by the elephant whose native food is the fresh green of the tropical jungle, and by the camel who at home contents himself with the bushes, the harsh grasses, and the young thorns of the desert. The deer and the moose also like it, although in their native homes they nourish themselves in winter almost entirely upon the twigs and branches of bushes which project above the snow, and such forage as they can get by digging in the snow.

Hay and City Dwellers. It may seem that this supply crop of the farm is of little interest to the city dwellers, but nearly all of them are indirectly dependent upon hay. Every time one eats beef, mutton, butter, milk or cheese, he uses a commodity that could not have been produced in usable quantities as agriculture is now practiced but for hay, and when there is a shortage in hay, dairy products and meat are higher in price.

Natural Hay. In the semi-arid regions, like the Great Plains of the central part of North America, nature herself makes good hay. Here the rain comes in the early summer, making the grass grow rapidly. With the increasing dryness of late summer, the grass dries and stands for months rich and nutritious. For centuries this natural hay has been an important part of the food of the vast herds of buffalo, antelopes, and other wild animals of the trans-Mississippi. This natural hay, being the prod-

[11] In 1900 we exported 1,380 million pounds of meat and imported 115 million; in 1939, we exported 246 million and imported 264 million. Our meat consumption by civilian population is a kind of mild prosperity barometer. In 1909, 155 pounds; 1915, 135; 1918, war boom, 142; 1921, slump, 134; 1925, stock market soaring, 140; 1935, depression, 115; 1939, armament program, 133; 1943, 136.6 despite enormous consumption by armed forces and allies.



Note that east of the 99th meridian the alfalfa crop is dispersed over the landscape in wide areas. To the west of the 99th, it is concentrated into spots, irrigated valleys. The South does not make much hay. There are not many animals and they can pasture for long seasons.

uct of a typical climate, is to be found in the other semi-arid regions. Human life depends on this wild hay when tribes live through the long dry season as do hundreds of nomad tribes by moving with their flocks from place to place in search of pasture.[12]

Distribution of Hay Production. The cultivated hay crop is general in the north temperate zone and also in parts of the south temperate zone, except on the pasture plains above mentioned and there it has had rapid increase in irrigated sections. In the United States, Canada, and Europe it is a very important crop. In the United States it exceeds the wheat crop in area, and about equals it in value. In value, corn of course far exceeds it, and cotton sometimes does. In Manchuria, Japan, and China it is much less important because of the small number of animals to be supported.

Relation of Hay to Other American Crops. Cultivated hay is usually made of the grasses known as clovers and timothy (the only important one of a thousand native American grasses[13] yet domesticated). Throughout large parts of the United States, and to some extent in Europe also, the common practice is to sow the grass seed in the fields of

[12] This great dependence upon wild hay is said to have crystallized itself into law. In the dry part of the year a fire once started in the hay will destroy it for miles. The fire itself may overtake flocks or camps and also destroy them. As there can be no more pasture until months later when the rains come again, the person who starts the fire may thus bring starvation to herds of animals and loss of human life to the people who depend upon them. As every people punishes most severely those offenses that tend to destroy society, death therefore is the penalty, in some parts of Arabia, for the one who starts a grass fire. No matter how accidentally it occurred, no matter how well meaning he may have been, no matter if it be the son of the chieftain himself, he has committed the unpardonable offense of imperiling the life of the community, and like the traitor, he must make the supreme payment—an excellent illustration of the influence of environment upon social phenomena.

[13] A striking evidence of the possibilities yet awaiting American agriculture in an age of scientific agriculture—if it should become general.

wheat, oats, rye, or barley when these small grains are sown, or in the early spring when the freezing, thawing, and drying of the ground open little cracks to receive the seed. The grass starts in the grain and fully establishes itself after grain harvest. The small grain is often spoken of as a nurse crop for the grass. Because of this nurse function farmers are often forced to grow small grain.

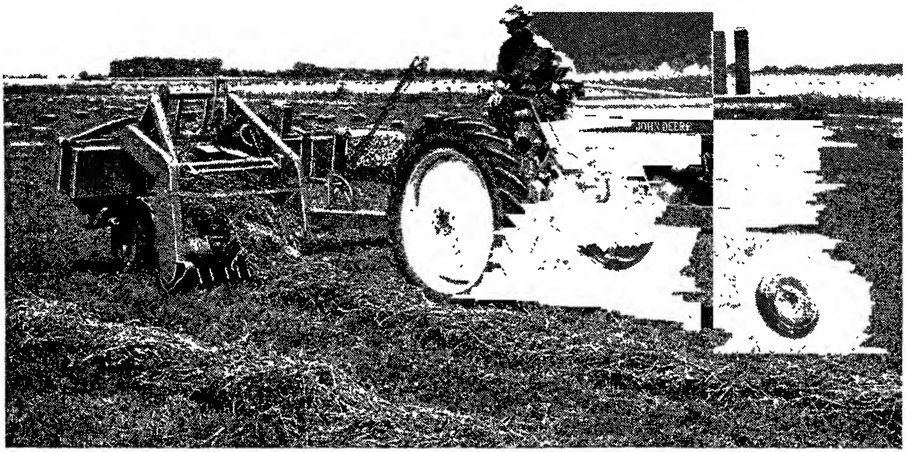
The Distribution of the Hay Crop. In the United States the Corn Belt is the great hay center also, a fact which shows very clearly that zones producing one farm crop only are not common. In western Europe, hay is important and has the same crop relationships as in the United States. In Europe the feed function of hay is performed in part by the great growth of turnips, rutabagas, and forage beets.

Methods of Making Hay. The Machine Age has come to the hay field and transformed things since Maud Muller performed her exploits. The mowing machine today cuts a swath, 5, 6, or 7 feet in width, as fast as the horses can walk or the tractor can pull. To let it dry out more rapidly, big rakes, drawn by horse or tractor invert it and roll it into piles. A kind of elevator called a hay-loader, often attached to a wagon, picks up the hay and puts it on the top of the load with the power of the team (or tractor) that pulls the wagon. Upon reaching the barn or stack, it is lifted off, hundreds of pounds at a time, by a hay fork or sling operated by the horses or tractor. A comparatively new machine, the pick-up baler, tractor-drawn, now sweeps up the hay and drops it off in bales. So great is the saving of labor that hay remains one of the cheapest of animal foods.

Hay in Commerce. The bulkiness of hay in proportion to value makes it comparatively unknown in foreign commerce. Some hay goes from the Corn Belt to the Cotton Belt where the humid summer does not encourage hay-making. Areas of intensive dairying, especially near to large cities, often buy hay. The many dairy farms of New England and the northeastern states make this region the greatest American hay market, and therefore the farmers of New York and New England find the selling of hay more important to them than do the farmers of other states. In many districts of New England it is almost the only crop grown and sold on many half-abandoned farms. The soil is so rocky that it is difficult to plow, but once the ground is sown with grass and the surface stones are picked up, hay can be cut year after year, with the result that in New York hay occupies over half of the total crop area, and in New Hampshire and Vermont it is more than four-fifths of the total crop area. The total hay crop of New England is, however, much smaller than that of an equal area of the Corn Belt, because of the much smaller proportion of the hay land that is in active cultivation, and the low yield of old fields.

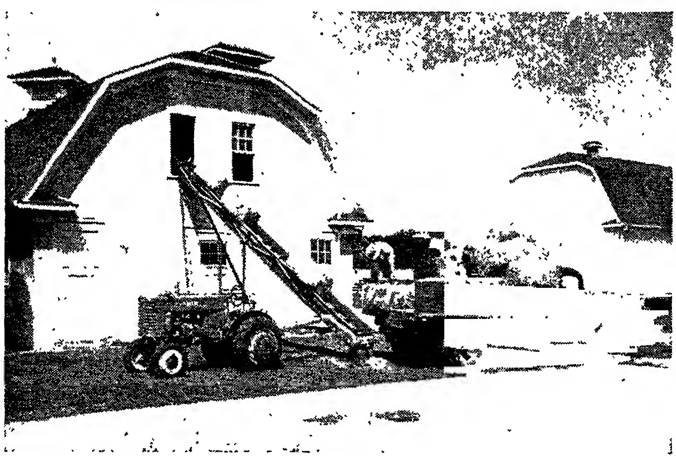
In Europe the function of hay as winter feed has long been met in part by root crops for stock feed—mangelwurzels, turnips, and rutabagas, which are grown in quantities entirely unknown in the United States, where corn silage more easily fills the hungry void. But corn silage is the giant upstart of the last 60 years.

Hay in Irrigated Countries. The best of all hay plants is the alfalfa, a legume which lives for many years, can slum-



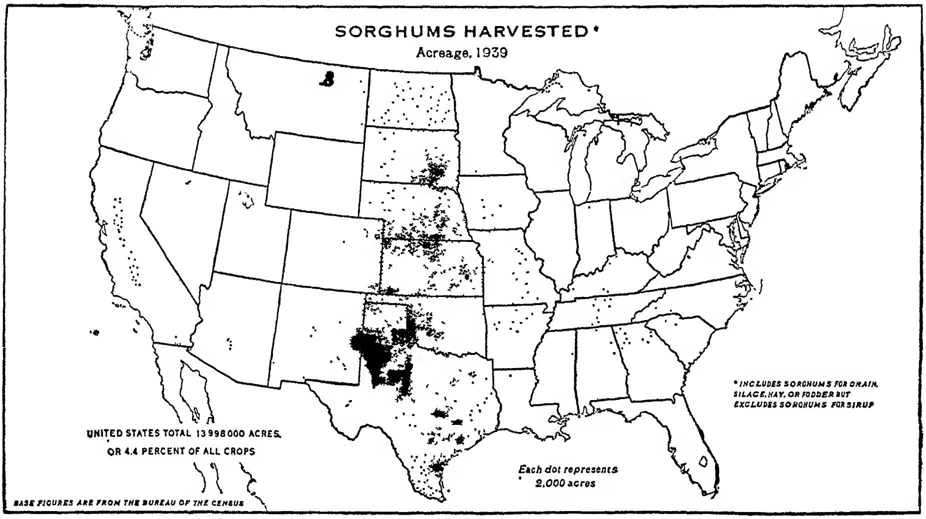
A

This pick-up hay baler has revolving teeth, showing white under the machine at the left. They pick up the hay from the windrow. A bale of it is visible over the tractor wheel. It is about ready to drop off. Many bales can be seen on the ground waiting for the truck to take them to storage.



B

The tractor operates a belt carrier up which the bales of hay ascend to the barn as they are unloaded from the hayfield truck. This kind of hay equipment is rapidly becoming standard east of the Alleghenies, but new improvements are coming swiftly on its heels, a machine that takes the hay from the windrow, chops it, drops it into a truck to be dumped out at the barn into a blower, which blows it into the barn even before it is dry. It may be dried by having air, ordinary air, forced through it under pressure from below. Another function of this grass chopper system is to carry green grass to the barn to be put into the silo for grass silage, another of the improvements in the dairy industry now advancing across the United States.

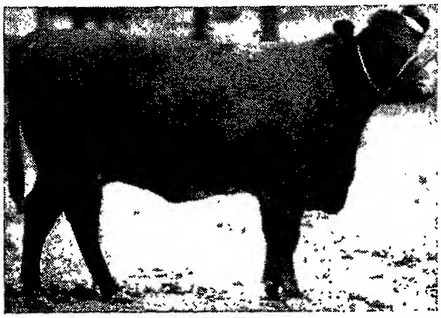


This map of sorghum production in the United States is a beautiful illustration of the adaptation of a crop to the land that may be called subhumid. It explains why Kansas and Nebraska have not held their own in corn production, but they are getting the same result from this sorghum plant, which has adjusted itself to lands of little rain in Africa and in the subhumid belt at the western edge of the Chinese agricultural area. It really is another corn from the standpoint of the nation's stock feed supply.

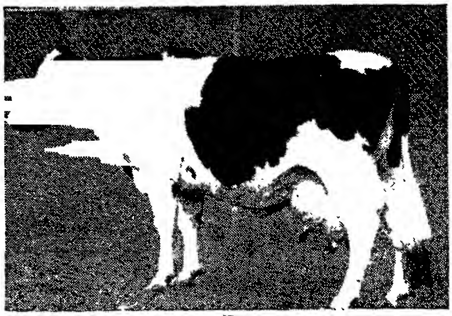
ber through months of drought, can spring into rapid growth the very day that water is applied, and can produce 5 or 6 tons of hay per season in three or four cuttings on rich irrigated land. It succeeds in altitudes ranging from below the sea level in the Imperial Valley, California, to 8,000 feet above the sea in the mountains of Colorado. To crown its virtues, alfalfa hay is rich, richer in protein than wheat flour, and has a forage analysis equivalent to wheat bran. Like other legumes it enriches the earth with the nitrogen nodules of its roots. Hay, therefore, reaches its greatest importance on the irrigated districts interspersed among the arid and semi-arid lands of the West, where alfalfa rounds out the food supply of the semi-arid ranges and makes satisfactory stock raising possible. The same combination is common in other arid regions, such as Chile, Argentina, and many parts of the Old World.

Hay as a Factor in Intensive Agriculture. As a whole, hay is more important to European animal husbandry than to the American. Europe has more cattle to the square mile than we have, and since cattle are rarely pastured, a large proportion of European land is in hay. Swedish hay is so vastly important that the poor peasant must in that unfavorable climate actually spread the grass out under sheds to protect it from the rain until it dries, and then shelter it for winter use. To get it to the barn it is at times brought down from the heights as in Switzerland on trolleys, traveling on wire cables. Such laborious conditions of agriculture as this explain the emigration of Scandinavians to America, and we see why people who had been able to live in such a country

quickly prosper in roomy America, with its more favorable climate and many opportunities.



A



B

Here are four pictures showing the effect of artificial selection in specializing the bovine breed to meet the different demands of beef and milk. This plump shorthorn cow has a small development of her milk function and a large development of beef function.

About the time of Christ, the two tribes, Friesians and Batavians, came via the Rhine Valley from Central Europe and settled on the fertile lowlands of the Rhine delta. One is reported to have brought white cattle and the other black cattle. That was about 500 cow generations ago and the cattle of the Batavians and the Friesians are still on the Rhine delta, but black spots have got on the white cows and white spots have got on the black cows, until we now have black-and-white Holstein Friesian cattle, heaviest milk producers in the world. This one bears the modest name of Line Gerben Pride Colantha Piebe, Number 1859291. It is not difficult to discern her milk function. Her record of 32,191 lbs. of milk, 1,207 lbs. of butterfat in 365 days, has recently been far surpassed by a record of more than forty thousand pounds by another of the black-and-white breed.

In warm weather, perspiration evaporating in our skins cools us, unless the humidity rises and checks evaporation. But cows can't sweat. They can only cool themselves by panting and when the air gets hotter than they are, they get a fever. This fact is now used to explain the low milk production of cows in our hot weather and in hot countries. Therefore, it is perhaps not an accident that the world's record milk production has been made by cows in the cool summer climate of suburban Seattle, Washington, almost identical to that of the Rhine delta, and adjacent sections of northwestern Europe whence came all the breeds of our important dairy cattle.

To the Icelanders, hay is a necessary link in a hard existence. The summer is too cool for grain. Wool is one of their chief money crops and to feed the sheep through their arctic winters, they literally shave their hummock hayfields with scythes.

6. *Dairy Products*

The Dairy Products and Their Uses. Milk, intended by nature only for the offspring of the particular species producing it, has been taken by man at various times and places from camels, mares, sheep, goats, reindeer, cows, the Indian water buffalo, and probably other animals. As a result of long selection and improvement, the goat and the cow have become especially adapted for this service and give quantities of milk which would have astonished our primeval ancestors who first domesticated the animals.[14] By artificial selection the breeds of domestic cattle have been specialized into two broad classes of different-shaped animals—the beef animals that get fat if well fed, and the dairy or milk breeds that give much milk if well fed.

[14] These animals render mankind an enormous service by making the best food in the world out of products which we ourselves cannot eat. The achievement of a record-breaking Holstein

A

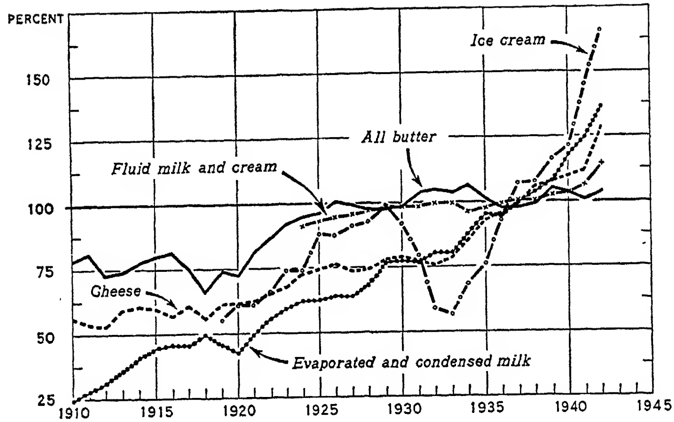
Front view of a beef cow.

Front view of a milk cow. This time a Jersey, native to one of the Channel Islands off the coast of France. Contrast the width of the beef cow and the milk cow.

The dairy products are first raw milk and then a number of manufactures of milk, chiefly cheese, butter, condensed milk, and dried milk. Milk is a perfect food, in that it completely sustains life, but dangerous because of the ease of contamination in its collection, and the further fact that it is a perfect germ culture.[15] There has been sharp advance in the cleanness of market milk, and the consumption of market milk in the United States nearly doubled 1928-43. Cheese, a condensed form of milk, is a substitute for meat (see Table 22); and butter is a fat, supplying well the deficiency of the albuminous and starchy

cow in this respect is astonishing. In six years and six months she produced 156,776 pounds of milk. The food consumed during a test year was as follows: pasture, four hours a day for nine months; concentrates, 5,872 pounds (ground barley, oats, bran, soybean meal, cottonseed meal, linseed meal); roughage other than pasture, 31,550 pounds (dried beet pulp, silage, alfalfa hay). This cow seems to have been a veritable factory. Just consider the 24,000 pounds of milk that she made annually from that collection of (to us) mostly inedible material.

[15] The relationship between the condition of the milk supply and a high infant death rate is often astonishing. "Oh! Isn't it terrible, Doctor?" said the weeping young mother. "The Lord has taken my dear little baby away." "Madam," said the doctor, "the Lord had nothing to do with it. It was dirty milk that killed your baby."—The cold but true words of science. Hence the science of sanitation.



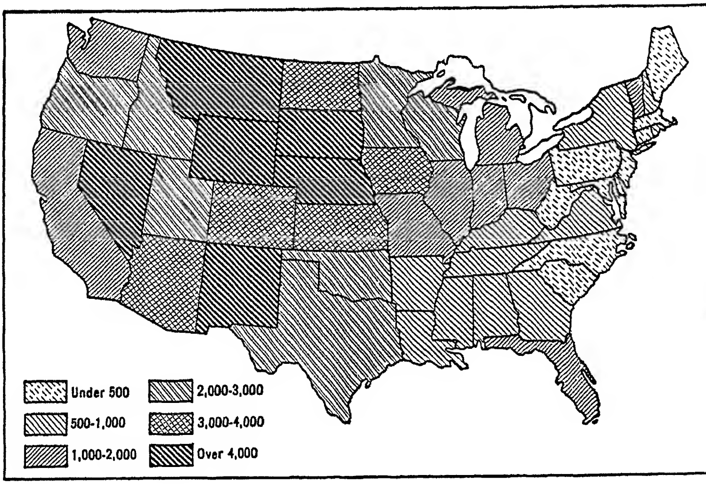
Dairy products and total civilian consumption in the United States, 1910 to 1942. Index number—1935 to 1939 equals 100.

The increase and decrease of consumption of dairy products in the United States, as here shown, suggests that we have a new industrial barometer—ice cream—if not industrial, then perhaps prosperity barometer. Apparently when we have the money, we eat ice cream. The rise of evaporated and condensed milk is also suggestive of an increasing standard of consumption and increased use in baby's bottle.

foods. For this reason it is so well liked with bread. All three of these major dairy products, especially milk and butter, are valuable in the preparation of many other articles of food.

Characteristics and Location of the Dairy Industry. Dairying as an important industry depends almost entirely upon cow's milk. It has arisen to the export stage in lands of moderate coolness where the rainfall is sufficient to make the succulent grass and other forage required by cows giving profitable quantities of milk.[16] Owing to the bulk weight and perishable nature of milk, it must be produced near to the market if it is to be consumed while fresh. The great demand for fresh milk in the vicinity of New York City has caused it to be brought over 400 miles in special express trains, such as those running from Wayne Co., Pa., and from the banks of the St. Lawrence to New York City. This big city receives some milk from Vermont and Maryland, and one-seventh of the supply from Pennsylvania, and some cream comes from Ohio and Indiana. In 1942, nearly two-thirds of the milk for metropolitan New York came by truck. Because of its nearness to large centers of population New York, the empire state, leads all other states in the quantity of milk shipped to city markets. Fortunately for the supplying of distant localities there are methods of condensation and preservation of dairy products. That part of the milk which separates as cream can be condensed into butter and kept for weeks, or, in cold storage, for months; the milk can be converted into white fleecy curds and the curds into

16 The coolness also is a factor in the cow's well-being. Suggestive fact—the records of most milk for 12 months oscillate [illegible] two cool areas—western Washington State and its climatic twin, England.



This map of dairy cows in the United States per one thousand rural inhabitants by states is not as good an index as it might be because the term rural population often includes small industrial communities, especially in the eastern part of the country. It is a better index for conditions between the Mississippi River and the Pacific coast than it is for the eastern half of the country.

cheese which keeps for months; and, by the processes called condensation and evaporation, along with hermetic sealing, milk can be reduced in bulk and canned so that it will keep for years. Thus, many parts of the world hitherto unaccustomed to dairy products have, since the development of world commerce, adopted their use. The West Indian planter opens tins of Danish butter in Jamaica or Puerto Rico, while condensed milk is to be found in the uttermost ends of the world where it is too hot to produce and keep milk, as in Guiana, or too dry, as in Cape Colony, or too cold, as in Alaska, or too mountainous as in Rocky Mountain mining towns, or wherever camper, prospector, or lumberman pitches his tent or builds his shack. Improved processes of drying milk by the spray process now produce a powder of great economic utility, and this industry is increasing rapidly.

Milk in the Factory System. The dairy industry was late in adopting the factory system. Well past the middle of the last century, milk was set away in shallow pans on the cellar floor for a day or two, to raise the cream to be churned in the hand churn—a thousand kinds to a county—no two alike.

Three master inventions have changed all this: (1) the cream separator in the 80's, a whirling machine that took fresh milk, and sent cream into one vessel and skimmed milk into another; (2) the Babcock tester, a tube and some chemicals with which anyone could tell how much cream was in the milk; (3) lastly the truck, accompanied by good roads.

The power-driven cream separator enabled a neighborhood skimming plant to handle the milk from ten or twenty nearby farms. The hand-driven separator, which came in the 1800's, let

any farm skim its own milk. This, with good roads and the truck, permitted tri-weekly, or even bi-weekly collection of cream by truck over a large area, and the manufacture of butter in a large and efficient plant. And so now Boston eats fresh butter from Dakota. Most of the cheese is now also made in factories rather than upon the farms of the people who keep the cows—another example in the long series of victories of the factory over home industry.

Dairying and Intensification of Agriculture. Dairying marks an important stage in the intensification of agriculture, which means increasing the income from a given piece of land. There are two ways by which a farmer may get more product. One is to take more land, the other to put more care and labor on the land he has. Where the population is sparse, little land is needed to produce the food, the price of land is low and the farmer can pay interest on its small value by cultivating a small part of it and pasturing the rest, and with a minimum amount of labor. Such is the characteristic of new countries, which are rarely dairy countries. The Great Plains of the United States are an excellent illustration. There are millions of cows, but the local production of butter, milk, and cheese in many localities is inadequate for the use of the few people who live there. The cow with little care from her owner runs upon the great range, and the calf which drinks all of her milk may never be seen by the owner until the day he is branded or sold. The wide level plains of Manitoba, Saskatchewan and Alberta furnish another example of extensive agriculture, this time in wheat. Wheat lands of low price make adequate returns with similar small labor, small expense, and low yield. In New York and other eastern states, on the other hand, the land is often hilly, the farms are usually small, and the farmer cannot grow grain so cheaply as does his brother upon the flat lands of Canada. His farm is so small and high priced that he cannot raise enough cattle to support his family if he uses the method of the beef producer of the Plains. (See ratios of classes of animals in Table 32 for cattle in 1944.) But a few cows eating his pasture grass, his hay, his corn fodder, and much of his grain will day by day produce enough milk to make him a living. Therefore, it comes about that the dairy cow is of great importance to the farmer on the rougher land from Maine to Minnesota. This operator of pastures, hayfields and silos produces vast quantities of market milk and the material for the manufacture of butter, condensed milk, and cheese. The United States still

TABLE 32

Distribution of Classes of Cattle, 1944

	Dairy Cows and Heifers		*Other cattle, 1,000's*
	1,000's	*Per cent total to cattle*	
Arizona	52	5.27	935
Wyoming	70	6.65	982
Texas	1,578	20.6	6,091
Massachusetts	135	69.2	160
New York	1,441	67.1	721
Wisconsin	2,526	63.9	1,421
North Dakota	608	33.2	1,226
United States	27,607	33.59	54,585

The Machine Age reaches the farm on rubber tires and helps to make milk, but machinery could not advance fully into the farm until gasoline and rubber were plentiful. Here the tractor pulls the corn cutting machine, which also chops the corn to pieces, elevates it and drops it into the truck alongside. Three men with two machines are doing the work that twelve do on farms that do not use the tractor and corn cutter. At the barn this truckload will be dumped into the blower, hoisted 40 or 50 feet into the air and dropped into the silo. The cows will be milked by a milking machine.

On a farm in the Piedmont section of Maryland in 1945, one man on a tractor pulling a cutter like this and two men with trucks put 10 tons in the two trucks in 40 minutes. Then all went to the barn and sent the chopped corn into the silo with a blower driven by the second tractor.

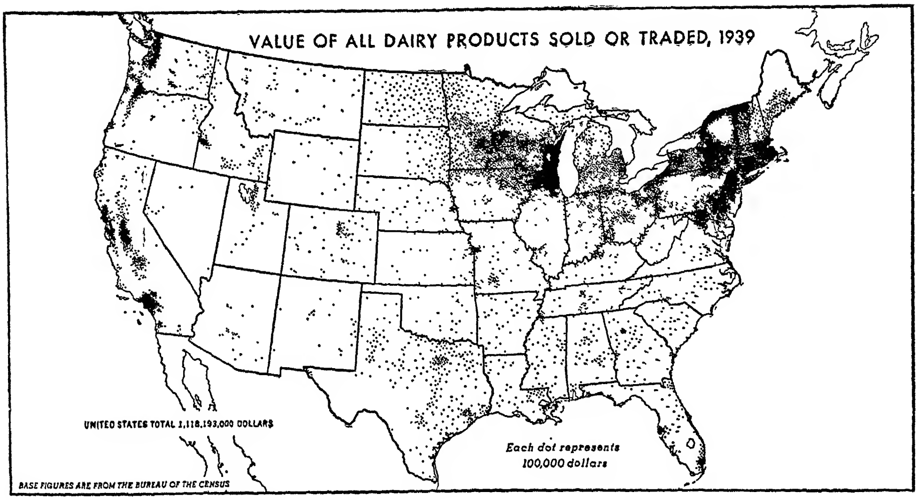
These three men put up 550 tons of corn silage that season, made other crops and milked 70 cows with milking machines.

The mechanical power was two trucks, 160 h.p.; two tractors, 60 h.p.; special engine on the cutting machine, 40 h.p.; total, 3 man power, 260 horsepower.

imports some European cheese, but virtually all varieties are now made in the United States by people who learned the art in Europe. Dairy products that are durable, condensed, and easy to transport tend to come from locations somewhat remote from the large cities, and their production is replacing the less intensive meat and wheat industries.

For several decades New York and Pennsylvania, our greatest centers of population, were also our greatest centers for dairying, but since 1900 the territory to the northwest of Chicago has taken the lead. The main dairy belt of the United States now lies just to the north of the region where corn and winter wheat are chief crops. The census of 1919 showed Wisconsin for the first time as the largest milk-producing state. Minnesota has turned from grain growing to the dairy cow and is now disputing second place with Iowa, which has passed New York state. North and South Dakota have taken to dairying but have remained static since 1925. The prairie provinces of Canada show a similar static tendency.

This gain of the dairy over the wheat and the meat industries is largely a result of high land values. Farm lands in the North Central States have in many districts tripled in value during the last 35 years.



This shows the *value* of dairy products used as farm income. On this map it is easy to pick out rough Appalachia, the rougher Adirondacks, rough Maine, the good St. Lawrence Valley, the sandy area of central Wisconsin, and certain irrigated spots in the west.

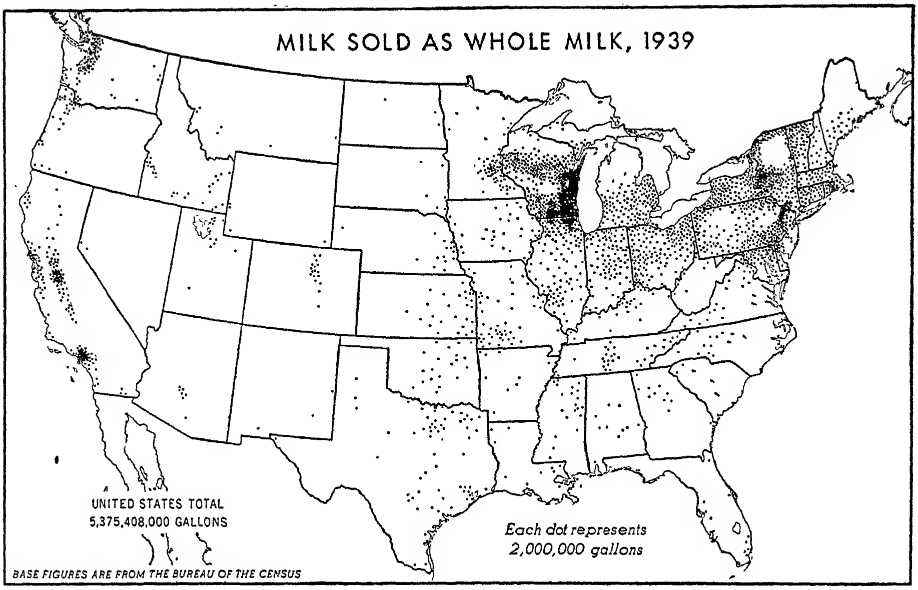
Wisconsin and the lower peninsula of Michigan developed a dependence upon dairy products earlier and to a greater degree than the states of the Corn Belt proper because their land is not quite so well situated for corn, and therefore the people were compelled to turn earlier from grain growing and make their land profitable by other means, such as potato growing and dairying. In Wisconsin, the state university has, through its school of agriculture, given conspicuous aid to the dairy industry by investigations, lectures, bulletins, class-room work and actual inventions, witness the very important Babcock milk tester. It has thus spread among farmers knowledge of the most scientific and profitable methods of dairying, and it has been an important force in bringing the state toward leadership in this industry (Table 33).

Canadian Dairying. That part of Canada lying between Lake Huron, the city of Quebec, and the American boundary, comprising the populous parts of

TABLE 33

Number of Dairy Factories in 1939

State	*Creamery butter*	*Cheese*	*Evap. and cond. milk*	*Ice cream*	*Total*
Wisconsin	418	1,817	92	141	2,408
New York	41	166	81	202	490
Minnesota	820	50	21	56	947
United States	3,506	2,682	562	2,734	9,484



This map represents quantities of milk. That which is sold to the creamery and cheese factories goes at a lower price than the bottled product on the urban doorstep.

Ontario and Quebec, is like Wisconsin and New York in its inability to compete with the level West as a grower of either corn or small grain. Consequently the people have long since turned to dairying and have reached a high degree of success through skillful use of state instruction and inspection. Great care is taken to maintain the high quality of the product, and it is consequently much esteemed in Great Britain and also in the United States. Our imports of Canadian cheese are increasing, and Canada exports over half of her cheese.

Dairying in Northwestern Europe. Northwestern Europe, with its good soil, cool humid climate good for cows and grass, and its dense population, has every requirement for a great dairy region and the scarcity of meat causes cheese to be used far more than in meat-eating America.[17] Table 34 on International Trade in Butter and Cheese (1938) merits careful study, as will the same table for 1948. Will the United Kingdom and Germany be able to buy, and if not can others sell?[18] The guns have ceased, but the economic echoes of this conflict will reverberate for years. An important source of prewar supply of butter and cheese was the great continental dairy belt which stretches along the northern plain of Europe from western France to Denmark, Sweden, and Russia. Throughout this whole belt the farms are small, and the rural population is dense, and while grain-growing is practiced on most of the farms, the keeping of dairy cows is also exceedingly common.

[17] A bulletin of the United States Department of Agriculture lists 242 kinds of cheese, most of them European. The prewar Dutch consumed 13.5 pounds of cheese per capita per year—the United States, 4.7 pounds.

[18] British loss of foreign investments and foreign markets, 1939-45, plus depression blows, are likely to play many kinds of far-reaching havoc.

TABLE 34

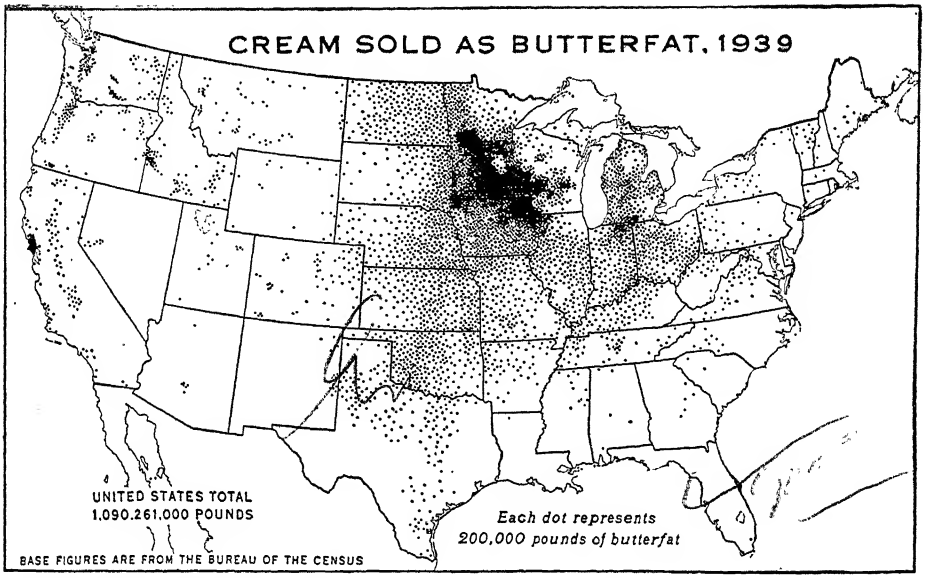
INTERNATIONAL TRADE IN BUTTER AND CHEESE IN 1938

(In metric tons)

Exports			*Imports*		
Country	*Butter*	*Cheese*	*Country*	*Butter*	*Cheese*
Argentina	7,336	1,979	Argentina	....	49
Australia	103,492	15,958	Belgium-Luxemburg	1,152	24,204
New Zealand	132,824	81,818	Norway	....	236
Canada	1,766	36,736	Sweden	1	1,223
Denmark	158,058	9,109	France	608	14,199
Finland	17,129	6,771	Germany and Austria	92,365	33,293
France	2,922	12,024	Italy	210	4,637
Netherlands	50,866	58,491	Switzerland	156	1,524
Italy	862	24,534	United Kingdom	483,529	148,714
Switzerland	5	22,384	United States	347	24,688
United States	888	672			

The north of France makes much excellent butter that goes to the great capitals of London and Paris. The Channel Islands between England and France, with daily steamers to London, have so long been important dairy centers that each of them, Alderney, Jersey, and Guernsey, has given its name to a breed of dairy cattle now widely scattered throughout the world. The town of Camembert in Normandy has given its name to a well-known brand of cheese and in the south of France is the town of Roquefort, where for generations the peasants have handed down from father to son the art of making from sheep's milk their famous cheese which is ripened in stone caverns deep under the ground.

The Netherlands, fifth in butter production and tenth in cheese, has been famed for its cattle since the days of Julius Caesar. Meadows, which the Dutchman has won from the sea by pumping out the water, were made by the rich mud that the Rhine has brought down from fertile highlands of central Europe. These moist, rich lands, too wet for tillage, make pastures of great richness. Here drainage ditches separate from each other the little green fields, dotted with feed boxes from which the black and white cows eat bran and grains imported from America. By this means farmers increase the number of cows they can keep. Since comfortable cows give the most milk, they are blanketed in the pastures during cold and rainy weather. These richly fed and carefully tended herds of the well-known Friesian or Holstein breed make dairy products the chief of all the farm products of well-tilled little Holland. The Dutch make 25 pounds of butter per capita per year. This is several pounds more than we make in



This map is a beautiful illustration of the fact that butter is more easily transported than fresh milk. Compare it with the dairy product value map (Figure 606).

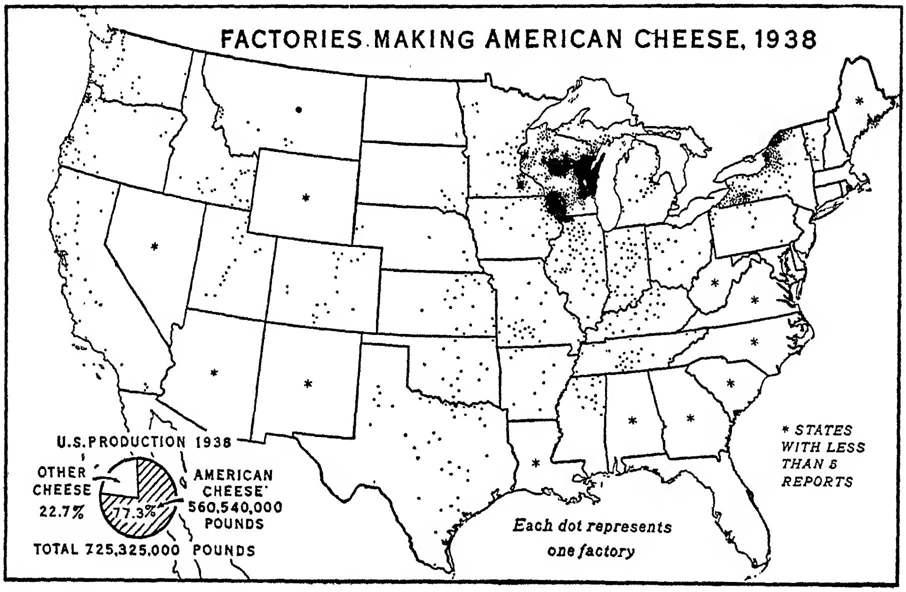
the United States. Their cheese output exceeds that of butter. The town of Edam, west of the Zuyder Zee, has given its name to a kind of cheese produced largely in that part of Holland, and, along with other Dutch brands, it went during prewar years to Germany, Belgium, the United Kingdom, France, and to many other countries where the fame of Dutch cheeses has spread. Holland has also become the leading producer of condensed milk, exporting a quarter of a billion pounds of it in 1939 and also a lot of milk powder.

In butter-making Denmark is the teacher of the world. Only about half the size of Maine, Denmark ranks fifth among the countries of the world in the production of butter, and first in volume of butter exports. The little country is visited by the agricultural scientists of all the world who would learn in its best form the art of dairying. Sixty years ago she was a meat exporter to Great Britain, but the need of greater income for a growing population has turned this democratic kingdom into a vast dairy farm with pig and poultry accompaniments. The Danish peasant owns a farm of from five to twenty-five acres. The land is usually sandy and was originally infertile but has become rich by good care and imported fertility in the form of cow foods carefully taken to the fields as manure. Five-sixths of the crop land is in barley, rye, oats and mixed grain most of which goes to the cows as does the grass and some root crops. The increase of land used for forage has encroached upon the grain fields until there is not wheat land enough for bread. In addition to a large import of bread grain, there is a considerable import of grain and grain products from America and Argentina to feed the cows. As a result, Denmark

with a poorer soil rivals Holland in having more farm animals for its area than any other country of the world; there are more than a thousand factories for making butter; the cows are inspected once a month to insure healthy stock; and the dread disease of tuberculosis, so common among housed cattle of the entire world, has been entirely stamped out of the kingdom of Denmark. The thrifty Danes import margarine to eat, and export their butter. The average income from such exports in 1937-39 to Great Britain alone was over 12 million pounds sterling. Through careful catering to the demands of the market, Danish butter preserved in tin cans has become the standard article for consumption in the tropics and in all the remote corners of the globe where there is no local supply.

The southern parts of Sweden, which are not far from Denmark, have also learned the art of making good butter; and the country, which in 1870 was a butter importer, is following Denmark's example. After 1918 there was a rapid increase in the export of butter. Ninety-eight per cent of total exports in 1932-36 went to the United Kingdom and Germany to pay for coal and steel. Russia exported butter before World War I and again in the 'thirties, and in the future is likely to be in a position to do so again—unless a rising standard of consumption enables the people to eat it all.

Swiss Dairy Industry. Switzerland has an interesting and unique dairy industry. Relatively large areas of land upon the high mountains, habitable only in summer, produce an abundance of



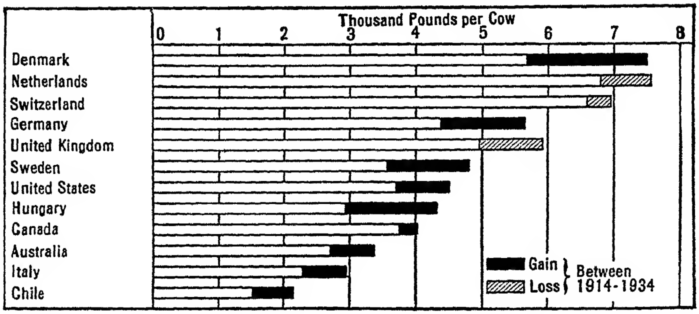
The market milk farm milks its cows 12 months of the year. Most of the butterfat farms (cream) also milk the cows 12 months, but the cheese factory often opens with the spring pastures and closes in the late autumn. It requires less winter forage for these cheese cows and they can therefore occupy the rougher land of northern Wisconsin, the edge of the Adirondacks and the hilly, unglaciated area of southwestern Wisconsin.

rich grass as the melting snow recedes and lets sunshine upon the saturated earth. The villagers of the valleys take their herds of cows to the higher pastures in summer, and, because of the distance, stay with them through the whole season, spending the nights in houses that have been built for the purpose. At intervals members of their families bring up the necessary supplies and take away the accumulations of cheese and butter which the herders have produced. On the lower slopes of the Alps hay is cut with scythe in the most terrifying places and taken down by wire, sled, man back, or quadrupedal pack animal. As a result of this careful industry, Switzerland is an exporter of excellent cheese, Gruyère being one of the best-known brands. She also exports condensed milk. Milk is also an important factor in the manufacture of milk-chocolate, in which Switzerland has long held a high reputation.

Milk in Mediterranean Lands. The small quantity of milk that is used, chiefly by children, in the Mediterranean countries of Europe with their summer drought is largely supplied by goats which can live on a poorer and drier diet than is possible for the cow. Some varieties of milk goats give a greater amount of milk in proportion to their weight and food consumed than does any other animal in the world. Furthermore, goat's milk is richer than cow's milk in both fat and solids. One of the characteristic street scenes in these countries is the milkman driving herds of goats through the street and milking them at the door of the customer, being able thus to guarantee the absolute freshness and purity of the milk—matters of importance in an iceless land.

In Italy commercial dairying is in the main limited to the irrigated lands of the Po Valley. The Alpine streams furnish water for the succulent pastures and hay crops which are responsible for the few brands of Italian cheeses that are well known in many countries of the world. Cheese production in Italy during 1931-35 was 15% of the world total. Italy ranked fourth in volume of exports. There has always been an important import of cheese, but since the turn of the century exports have been exceeding imports. During this time the United States shifted from an export to an import of cheese. Cheaper cheeses are imported into Italy to feed her own people just as the Dutch and Danes import oleomargarine from Chicago for their own use and sell the butter that they make. Oleomargarine, a butter substitute, has virtually the same chemical analysis as butter, but the vitamin content is not so high. Being made chiefly from suet (body fat of beef) the possibilities of cleanliness of manufacture are ahead of those in butter.

The comparison of dairy exports (see Table 34) from the United States—vast, rich, and agricultural—and from mountainous and populous little Switzerland, with half her used land in hay, is striking even in absolute quantities. On the per capita basis, Swiss cheese and milk exports in 1939 exceeded the entire exports of the United States in grain and grain products, animals and animal products. Thus the Schweitzer, like the Dane, makes the most of his limited opportunities, and the American, with more resources, does not have to use them so closely. It is evident that com-



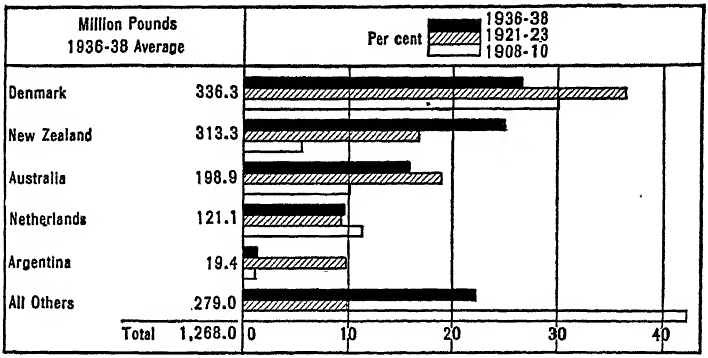
The milk yield of the average cow per year and her progress in a thirty-year period. The cow that gives 15,000 pounds of milk does not eat five times as much as the cow that gives 3,000. She occupies no more barn room, so she is in every way advantageous.

The actual yield of a cow depends on her breed, her owner, the climate, her feed, her physical comfort and her peace of mind. Apparently some of our European neighbors were unable to keep up their feeding and breeding schedules.

mercial dairying depends more on the distribution of laborers (density of agricultural population) than on resources —another example of production in a place not best fitted for it. In dairy possibilities America greatly exceeds Europe.

America's greatest superiority over Europe as a place for the production of dairy products is the priceless boon of corn, the king of forage crops for which the people of all European dairy regions must substitute the laboriously produced beets and other root crops and the less productive barley. The American Cotton Belt has even better dairy possibilities than the Corn Belt, but it imports from glaciated Wisconsin. In 1939, the United States imported 59 million pounds of cheese and exported 1½ million.

Australasia and Refrigeration. The refrigerator ship which has revolutionized the meat supply has made possible the importation of butter and cheese from the most remote countries. Thus New Zealand, which is almost exactly on the opposite side of the world from Great Britain, has been able to attain front rank in dairying. New Zealand ranks sixth in volume of production of cheese and butter. It exports more than three-quarters of the product. For the period 1931-35 New Zealand exported almost one-quarter of the world's butter, and one-third of cheese, being second in butter (exceeded by Denmark) and first in cheese. Ninety-seven per cent of the butter went to the United Kingdom, and practically all the cheese. If Britain cannot keep on buying—? This country, nearly as large as Italy, has a splendid rainfall owing to the prevalence of the constant west winds from off the great southern seas. The government has taken great pains to inspect and guarantee the quality of exports. In exports of cheese she passed the Netherlands during World War I and has since held first rank. Her combined butter and cheese trade easily gives New Zealand world supremacy in the export of these dairy products. This country is still in the frontier stage of



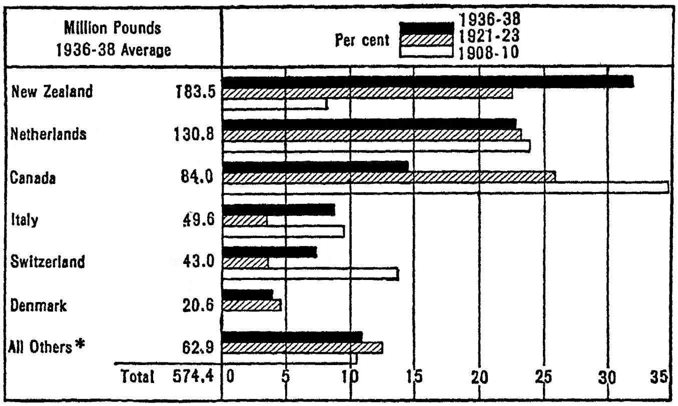
World export of butter, three-year averages, percentages for the three periods, quantity for the past period. The United States has several times the butter possibilities of Denmark, New Zealand, and Australia combined, but our industrial and resource situation is such that we do not have to export butter, a market in which there is fierce competition.

scanty population, but her very remote situation brings her early to the shipment of milk products rather than meat products.

Australia, the Texas of the Antipodes, being further north, and out of the latitude of steady rains, has her production of dairy products sadly interfered with by the droughts. Consequently the industry, less important than in New Zealand, is chiefly limited to New South Wales and Victoria, the most southerly, the coolest, and rainiest part of a warm dry continent. Australia has become the third butter exporter, but drought makes the quantity fluctuate.

Argentina has a climate particularly favorable for livestock raising and is just beginning to turn from beef production to dairying. While considerable butter is made and exported to Europe the dairy industry as a whole is slow in getting a foothold. There are several reasons for this condition. One is that the cows are only pastured and do not receive concentrated foods, hence the butter yield varies with the season. Another is that it takes great care to make good butter and cheese in a warm climate. The sparse population of this new country does not furnish the labor which such intensity of agriculture as dairying demands, and the labor supply in Argentina has not yet developed a propensity for that class of work. The vicious landlordism of the absentee Spanish owners of the great haciendas (estates) is another reason.

Dairying, of all the great agricultural industries, is the most exacting in its labor requirements. The cow must be milked morning and evening the year around; she must be treated gently by a really civilized person; the cow, the product, and utensils must be kept clean. These qualities have been developed chiefly in connection with the keeping of cattle by the Teutonic peoples from north Europe. The Spanish and Italians who make up the bulk of the population of Argentina have not had ancestral training in keeping cattle, but they are gradually creating a new source of dairy products in the southern hemisphere because steadily rising prices demand new sources of supply.



World export of cheese, three-year averages, by percentages for three periods, by quantity the last period. The situation in the United States in the export cheese business is in the main similar to that of butter. The business is highly competitive. The fact that Italy exports any is a measure of her extreme poverty as a nation and lends some support to a well-wisher for humanity, who said that no undernourished nation should be allowed to export a basal food product.

Possible Extension of Dairy Areas. The keeping of milk products without ice or cold spring water is so difficult that people in most warm climates were virtually unable to make good butter or cheese before the improvements in dairy machinery and artificial cooling. Now that the steam engine or electric motor can make ice and a cold room anywhere, the tropics or the Cotton Belt of the United States can, so far as climate is concerned, compete on an almost equal footing with Wisconsin or Switzerland. It requires a large number of cows, 200 to 500, to support a creamery with cold storage attachment. The way is now open for the geographic extension of dairying. At the present time it is an industry largely but not necessarily restricted to the cooler parts of the world. It may become more common for the warm lands rather than exceptional, as is the present export of small quantities of native African butter, which is sent to Europe for reworking from the highlands of Tanganyika, Kenya, and Uganda.

Alabama reported its first cooperative creamery in 1922, and cows are increasing in the American South. Thousands of cotton plantations could maintain their cotton output and also become dairy farms if demand created effective labor there. It is a matter of relative advantages, including human energy.

In many parts of China and Japan dairying is almost unknown for reasons made evident in the section on meat and cattle, and any large increase is improbable or perhaps one should say impossible.

7. *Dairy Substitutes*

The Butter Substitute of the Dry Subtropic Climate. Milk production is at a low ebb in lands of little rainfall, or of summer drought, such as we find in

California and the Mediterranean countries, because of the scarcity of grass. During the months of summer drought, the cost of supplying milk animals with green and succulent food is so great as to make milk relatively expensive and something of a luxury unless there is large opportunity for irrigation.

Fortunately, the Mediterranean climate furnishes a partial substitute in the fat of olive oil which replaces butter in the diet of the people of Mediterranean shore lands. Figures of consumption are illuminating—butter, 1938 per capita per year—Canada, 30.8; United Kingdom, 24.8; U.S.A., 13; Italy, 2.6; Spain, olive oil, 26.4. In that year Spain (in the grip of civil war) produced 33 pounds of olive oil per capita; Greece, 60 pounds on her poor old eroded rocky hills.

The olive is a wonderful food producer. It grows in poor, rocky hillsides from Gibraltar to Jerusalem and from the Sahara to southern France. Its oil, unlike most of the animal fats, does not easily become rancid.

We have seen prosperous trees thriving in the gulches of central Tunis where the rainfall was only seven inches per year. Again we have seen Tunisian trees prosperous and bearing which were undoubtedly planted before the incursion of the Arabs in 648 A.D. This lends possible truth to the legend that the olive trees under which Jesus walked in the Garden of Gethsemane may still be standing.

Many restaurants in American cities, run by people from the Mediterranean basin, serve good meals, satisfactory to the American taste, using olive oil entirely in place of butter.

Dairy Substitutes in the Rainy Tropics. The hot and rainy regions of the earth favor neither the white man nor his milk-giving animals. For the production of dairy substitutes, however the tropics are well fitted except for the matter of vitamins. Butter and cheese are but digestible fat and protein plus the indispensable vitamins. Many vegetable oils furnish very similar fat, and there are many cheaper proteins than that of cheese. Two of the most promising dairy rivals are found in the oily coconut and the nutritious peanut. These little-used plant products have made a late start on a career of usefulness that is exceedingly suggestive and carries the possibility of a partial revolution in food supply and production.

Nearly half of the meat of the coconut is fat or oil, and the nut has the quality unusual among oily vegetables of keeping for many months without becoming rancid. Some chemist worked another atom of hydrogen into coconut oil, which changed a strong-smelling liquid into a firm, tallow-like, white solid with no unpleasant odor and the butter substitution process began apace. In a short time the German chemists had made a nice-looking butter substitute, golden yellow with egg yolk and flavored with a little cream. It spread through Europe like new styles in clothes. Boatloads of copra went up the Elbe to central Europe. Oil mills arose in every great port, and by 1912 the European margarine factories, using coconut oil as a base, had a greater product than the whole international trade in butter.[19] During the 1920's and 1930's, whale oil entered largely into European

[19] Among the many results a firm in Wisconsin, our leading dairy state, advertised nationally that it made a butter from coconut oil. Another firm advertised, for cooking purposes, a "filled" milk

margarine, but the whale is going the way of the bison. Not so the coconut, or the peanut. The figures of imports of coconut oil and copra, dried coconut meats for pressing, are impressive and they would have been larger but for the American tariff.

With increasing demand, additional coconut oil can be produced more easily than butter, because large areas of unused land on nearly all tropic continents and islands are suited to the coconut palm. In the Dutch East Indies, the Federated Malay States, the Philippines, and thousands of lonely islands in the South Seas the coconut has for an unknown time been an important, in some cases almost the only, element in the economic life of the natives except fish. It is easy to raise a product that grows without cultivation, falls from the tree embedded in a thick cushion of husk, and lies for weeks safe and sweet, waiting to be picked up. A good coconut tree produces 50 to 100 nuts annually;[20] 4,000 to 7,000 nuts make a ton of copra yielding 100 gallons of oil. The food possibilities of coconut-growing sound almost too good to be true. "When his coconut trees begin to bear, he hangs up his hammock"—tropic adage.

The peanut may be considered as a partner of the coconut in this vegetable onslaught on the animal industries. It has gone from the peanut roaster on the sidewalk into the eight-story factory and has become a staple and increasing article of food and a staple cooking fat. The peanut per pound is nearly as nutritious as cheese, contains more protein than a pound of sirloin steak, plus more carbohydrates than a pound of potatoes, plus one-third as much fat as a pound of butter. It has more nourishment than a pound of sirloin steak and a pound of white bread combined.

TABLE 35

IMPORTS OF COPRA AND COCONUT OIL
(In million pounds)

	1913		*1925*		*1939*	
	Copra	*Coconut oil*	*Copra*	*Coconut oil*	*Copra*	*Coconut oil*
United States........	30	72	215	216	429	336
United Kingdom....	69	130	128	148	254 *	86
Denmark...........	68	..	125	..	165	9
Netherlands.........	221	36	195	114	166	14
Norway............	..	8	..	26	76	1

* 1938.

made by taking skimmed milk from the creamery and restoring the normal amount of fat from vegetable sources. Owing to its non-content of vitamins the dairy interests, through Congressional law, were able to get this commodity barred from interstate commerce.

[20] It is not rare to find individual trees which mature 15 nuts per month or at the rate of 180 nuts a year.—E. V. Wilcox in *Tropical Agriculture.*

Now that we are in a period when growing population and high prices force us to look about for new food sources, the peanut offers a most valuable addition to our diet and to the diet of our animals. In Europe its chief use is in the form of edible oil, taking the place of lard, butter and olive oil, for which it is now one of an increasing number of substitutes. A bushel of peanuts weighing thirty pounds (hulls included) will produce a gallon of edible oil when crushed, and twenty pounds of cake, a stock food high in protein and especially suited for dairy cows and the feeding of growing animals.

The fact that this leguminous plant is at home from latitude 37° north, clear into the south temperate zone, and can be grown successfully in sandy soils of low fertility, marks it as one of our greatest crops for the future. It has already become a staple of Cotton Belt agriculture.[21] Tributary to Norfolk, Va., and a few miles back of the truck center is the greatest peanut-growing center in the United States. The town of Suffolk, Va., the market and manufacturing center, is fragrant with the odor of roasting peanuts.

Peanuts are exported from British India, Senegal, Nigeria, Manchuria, China, Gambia, Portuguese Guinea, Netherland Indies, French Cameroons, Sudan, Tanganyika, and Argentina. It is perhaps our most catholic crop. Is there another that is produced and sold by the white, black, yellow, and brown races? Like the coconut in its husk, the unshelled peanut keeps in perfect condition and can wait while man takes his time to prepare and ship. Any patch farmer can grow them. These two nuts are an admirable example of the shift from animals to plants as a source of food supply, and the shift of support from cool to warmer lands. As population, land values, and cost of living steadily rise in the cool temperate zone, the pressure comes most keenly on the animal products because of the large amounts of land required by the animals. It is decidedly comforting to find such satisfactory substitutes in the palm and peanut which so nearly furnish diet equivalents and are so well suited to the vast areas of the fruitful tropics, and to growth by the native populations already inhabiting those lands.

A few years ago cottonseed was a waste product, the main problem being how to get rid of it at the least expense. Then chemical research showed that the seed contained a valuable food oil and that the cottonseed cake left after the oil was pressed out made a nutritious stock feed. The manufacture of cottonseed oil is now an important industry throughout the South, over 4 million tons being crushed annually. A ton of cottonseed makes from 36 to 40 gallons of oil, of which about 40% is made into lard or butter substitutes. It resembles olive oil in food value and is sometimes refined and used as a salad oil. The great richness of the cottonseed meal in protein led to its utilization as food for dairy cows, for which it is shipped to every important center of butter and cheese production in the United States. Its satisfactory use as a breadstuff for human food has been demonstrated, but human beings change their diet much more slowly than cows do.

[21] The fact that it can be harvested by the pigs adds to its importance. It is extensively grown for this purpose in Georgia and Alabama.

The great importance of the soybean in China and Japan for many centuries past did not cause the western world to pay much attention to this crop until a very late date. Are we smart, or are we stupid? This bean is now skyrocketing into importance in the United States. In 1929, we harvested 700,000 acres, and had 9 million bushels. In 1943, we harvested 11 million acres, and had 195 million bushels. In 1943, four-fifths of the crop were grown in Ohio, Indiana, Illinois, and Iowa.

This bean crop fits nicely into Corn Belt farm practice and machine production. The plant breeders are performing wizardry in getting new varieties with different qualities. Most of these beans have at least 18% oil, so the ten pounds of soybean oil per bushel (costing 75¢ to $1.50 at the farm) gives us a very cheap source of edible fat and a rival for cottonseed oil, peanut oil, olive oil, and all the rest of the long series.

The cake remaining after the oil is pressed out is an excellent stock food, rich in protein.

The vegetable oils we have enumerated are merely members of a class.[22] The sunflower seed has 30% of oil and is also edible.

From Nigeria come reports of vast amounts of oily nuts of the shea tree which promptly begin to be exported by thousands of tons as soon as the railways open up new districts. This is prized as a butter material by the people of the interior, as is the palm nut of the coasts. Like the palm nut, the shea nut has quickly entered commerce. Palm oil and palm nut oil, product of a palm tree growing in the tropic forests of Africa, has risen to the height of great export for many African colonies. It is used for food and many other purposes in Europe, has been introduced into the Dutch East Indies, and has become an important export from those islands.

In Brazil, the babassu nut (a palm) is reported to have great commercial possibilities. This nut, considered in light of the palm nut of Africa and the many other oil-producing nuts of the tropic forests, is very suggestive of what we may do with a few more decades of peace, sanitation, scientific utilization of the tropics.

8. *Sheep and Other Wool Bearers*

It is generally thought that our ancestors found the sheep upon the mountains of central Asia, a mottled animal of black, white, and brown, whose pelt has made us the best of all protections against the cold and aided our advance into the land of frost and snow. To this day millions of Asiatics in the interior of that continent protect themselves from the bitterness of its winter with sheepskin coats and caps, and history contains no record of the origin of cloth making, so remote was its beginning.

For many ages before the coming of cheap cotton (sometime around 1800) woolen cloth was the chief clothing material in the temperate zone, and sheep were much more universally kept

[22] The special report on Vegetable Oils and Oil Materials in International Commerce, Dept. of Commerce, Miscellaneous Series 108, 1922, called attention to the fact that there were then at least fifteen major vegetable oils and oil materials from four continents in our own import trade. This report gives interesting statistics for many of these oils, of which the following are the more important edible oils: cottonseed, coconut, peanut, soybean, palm, olive, mustard, rape seed, sesame, hemp seed, sunflower, and castor bean, which, by the way, when boiled is a good, edible oil.

than they now are. In the springtime their winter coats were shorn to serve their masters the next year, and lamb flesh had been prized long before it was prescribed in Hebrew Law as an offering to Deity.

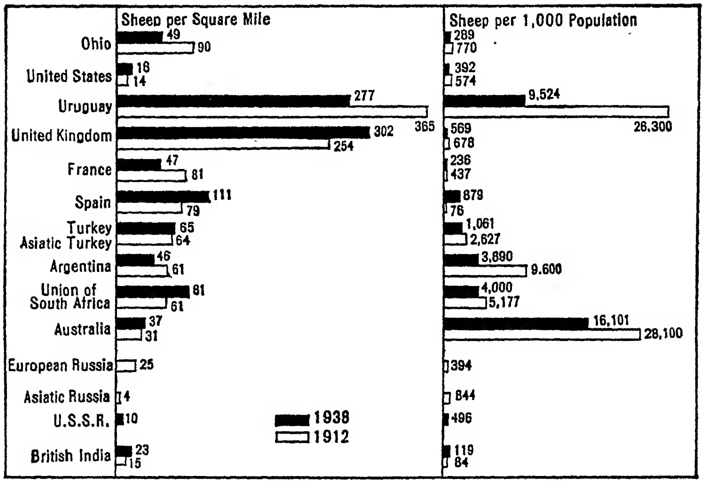
The Old Testament shows that sheep were of great importance to the peoples at the eastern end of the Mediterranean Sea, and they were but little less important to the early Greeks, Romans, and the barbarians who overwhelmed the Roman Empire.

Sheep Breeding in Britain. For several centuries both before and after the discovery of America the export of wool from England was the great basis of foreign trade in that country. The island location gave it security from foreign invasions, and peace led to the internal order which is necessary for the satisfactory development of sheep flocks. People may return from war and find their cattle, but sheep, weak, defenseless, stupid, subject to disease, the easy prey to accident, dogs, and thieves, need constant care. Thus it came about that England, the most peaceful country of Europe, had a relative monopoly in wool, and it has developed most of the important breeds of sheep. English pastures also are among the best in the world and very *dependable*. Dependability is a geographic factor to which more emphasis will be given by future writers.

The names of the breeds show their British origin—as Lincoln, Cheviot, Cotswold, Dorset, Southdowns, Hampshiredowns, Oxforddowns, Leicestershire, and Highland sheep. The judges of the highest English court have for centuries sat upon a wool sack—symbol of the commercial importance of that commodity and also of the origin of British courts. The best breed of sheep for wool production, however, is the Merino, a breed developed on the high plateau of Spain from sheep whose ancestors originally came from Africa. This sheep, famed for its wool, was jealously guarded by the Spanish and for centuries they would not let any of them leave their country, but during the eighteenth century they spread to Germany, France, England, and America.

Factors Affecting the Distribution of Sheep Industry. Before the beginning of the railway epoch, sheep were distributed upon the farms of Europe and America, and most countries were nearly self-supporting with regard to supplies of wool and mutton. But the period of world settlement and world commerce following the railway and steamship about 1850 led to an entire revolution in the sheep and wool situation of the world. A sheep industry on the largest scale that has ever been or is ever likely to be seen, resulted from the throwing open of large areas of land in North and South America, South Africa, Australia, and central Asia which could be best used as sheep ranges.

Probably because of mountain ancestry, the sheep is a good climber for rough pastures, and a good traveler. He can go far for his food and water or to market. By eating dewy grass at early morn he can get along with little water. His sharp nose enables him to reach into the crannies of rocks for scanty herbage. His cleft lip lets him almost eat the roots of grass, often to the detriment of the grass. Altogether he is well fitted for the utilization of land not fit for the plow, and regions with greatest



The ratio of sheep to land and to population at two periods shows interesting shifts with many declines.

dependence upon sheep are those parts of the earth's surface which for some reason are not thus available for cultivation. It may be that the land is too rough and too wet, as in the Scotch Highlands with their heavy rains. These hills would naturally be covered with luxuriant forests, but are entirely barren of trees because for centuries sheep ranged the forests and ate every young tree that came up until finally when the old trees died, the land was left for grass and heather upon which the sheep flocks have in some cases subsisted for several centuries. Similarly, certain hills in the south of England bear to this day the names of forests, although for many generations they have been treeless pasture lands devoted to sheep flocks. Thus, Cotswold (meaning wood) Hills, like the South Downs, long ago gave their name to a breed of sheep.

Semi-aridity, however, is the greatest reason why land is devoted to pasturage of sheep rather than to cultivation in grain and other crops.

Thus, the plateaus of dry Spain have been famous for sheep since the times of Hannibal and Caesar, and, although the fine-wooled Merino breed originated there, most of the Spanish flocks are those yielding coarse wool. The greatest flocks in the world are upon such semi-arid plains in Australia, South Africa, Argentina, western United States, and Soviet Russia, yet the fact that some of these lands are hot, and do not naturally suit the sheep, is another illustration of an industry in a place that is not best suited to it. The sheep with his warm coat is equipped for cold climates; the fleece degenerates in hot lands, the wool entirely disappearing in Cuba and Brazil, leaving only the hair coat of which all sheep possess a little. In Australia, the tendency to degeneration because of heat has been overcome by the constant importation of fresh breeding stock from England, Vermont, and other localities where the sheep is at his best.

TABLE 36

Numbers of Sheep (Selected Countries)

(In millions)

	1911	1923	1939
Semi-arid countries:			
Australia	92.4	82.2	111.1
Union of South Africa	30.7	31.5	38.4
Algeria	9.0	9.0	6.0*
Spain	15.1	19.3	21.8
Italy	11.2	11.7	9.9
Greece	4.6	5.8	8.1
Turkey	6.9	11.2	19.0
Asiatic Turkey	45.0		
Russia	38.0	9.3	84.5
Chile	3.6	4.5	5.6†
Mexico	3.4	.3	6.2
Countries partly semi-arid:			
United States	52.8	38.3	51.6
Argentina	67.2	30.6	49.8‡
Countries of scanty population, good rainfall and remote from markets:			
Uruguay	26.3	14.5	20.0†
New Zealand	24.0	23.0	31.9
Countries with highly developed agriculture:			
France	17.1	9.7	9.9
Germany	7.7	6.1	4.8
United Kingdom	30.5	24.1	26.9
Belgium	.2	.1	.2
Denmark	.7	.3	.1
Switzerland	.2	.2	.2‡
Total of the world	615.2	500.0	506.0

* 1938.
† 1940.
‡ 1941.

Source: U. S. Dept. Agr.

Value of Sheep to Regions Remote from Markets. A third reason why land may be devoted only to sheep is its inaccessibility for the marketing of the heavy and less valuable products of agriculture in which transportation costs must be relatively high. Grain requires a railroad close at hand. Cattle, unless their meat can be marketed, have nothing to yield but the hide and tallow which is relatively of less value than the fleeces, skins, and tallow of sheep. Consequently, sheep flocks give the people of remote plains the greatest possible cash income, and the opening of new lands between 1850 and 1890 caused an enormous increase in the number of sheep throughout the whole world.

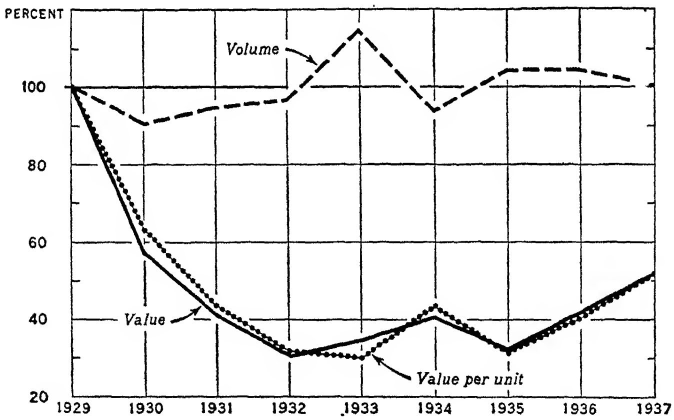
The Falkland Islands afford an excellent illustration of the service of sheep to the people of a remote land. This group of islands, more than half as large as Maryland, is located in the South Atlantic Ocean opposite Cape Horn in a latitude corresponding to southern Alaska and Scotland. The rainfall of the islands is good, but the climate is cool and there is no tillage because the prevailing westerly winds of that latitude blow so hard that even trees cannot live because they are blown out of the ground. Yet these windy plains and hills produce good grass and for each of the 2,435 people the islands have 1¼ horses, 4 cattle, and 256 sheep. It requires a very small population to utilize the land in this way, and as a result the people are so scattered upon their large sheep ranches that the public schoolmasters must travel from ranch to ranch to teach the children in their homes. The Islands of Faroe and Iceland in similar but northern latitudes also have a great dependence upon the export of sheep products.

Importance of Sheep in South Temperate Zone. The south temperate zone with its large plains in South America, South Africa, Australia, and New Zealand, is the part of the world having the greatest dependence upon sheep. This

zone, with less than 1½% of the world's people, has about 40% of its sheep. Taking the world over, there is about one sheep to three persons, but in the south temperate zone, which combines the qualities of remoteness, semi-aridity, and sparse population, there are about five sheep per person.

Where sheep are kept upon the open plain there is a special method of caring for them. Owing to the defenseless character of these stupid animals they require constant care and may not be allowed to shift for themselves as do cattle or horses. In all regions of large sheep production the method of caring for them is much the same. The herder with a couple of dogs and usually a camp wagon and pair of horses takes a flock of one to three thousand sheep and follows them for days and weeks, being met at appointed places by supply wagons sent out by his employer. The sheep dogs, with the inherited qualities of many generations, are much more skillful helpers in driving them than men could be, and the herder's rifle protects from wolves, foxes, and dogs, while the flocks are sometimes put into corrals or fenced enclosures at night.

Australia has long been known as the greatest of sheep countries and the leader of wool exporters, with two-fifths of the world's total (1938). That continent, which is about as large as the United States, has a mountain barrier parallel to the eastern coast which shuts off from the interior most of the rain brought by the southeast trade winds. The narrow plain along the coast is good for corn and other agricultural crops requiring moisture, but west of the mountains the wide expanses of plain that slope gently away from the sea have only enough rainfall to produce good grass. Some of the finest sheep ranges in the world lie between these mountains and the grassless desert which occupies the central and western parts of the continent. The railroads that connect the ranches with the eastern ports reach almost to the desert, and



World exports of wool, volume and gold value, 1929-1937. Index, 1929 equals 100. Here is another member of the family of agricultural ruin by the great depression. It was this that helped to create the Australian tariff because the agricultural exports would not pay interest on the debt to Britain and leave money to buy goods from Britain.

all the land that has any value has for some decades been occupied by the sheep flocks. Australia is unfortunate in the arid nature of much of her territory and also in the irregular character of the rainfall. Droughts sometimes last for long periods, cutting off both grass and water so that the sheep starve by millions, as in the period 1894 to 1898 when

TABLE 37

SHEEP AND CATTLE IN AUSTRALIA

(In millions)

	Sheep		*Cattle*	
	1921	*1939*	*1921*	*1939*
New South Wales...	33.8	54.4	3.3	2.7
Victoria...........	12.3	18.2	1.7	1.8
Queensland........	18.4	24.2	7.0	6.2
South Australia.....	6.3	9.9	.3	.4
Western Australia...	6.5	9.6	.8	.8
Tasmania.........	1.5	2.7	.2	.3
Northern Territory..	....	....	.6	.9
Total.........	78.8	119.3	13.9	13.1

continued drought reduced the sheep flocks from 110 million to 84 million. The great dependence of the flocks upon rainfall and rainfall fluctuations is shown by the observations of a scientist who says that with 10 inches of rainfall per year, an Australian plain will support ten sheep per square mile; with 13 inches of rain, twenty sheep; and with 20 inches of rain, seventy sheep. With less than 10 inches of rainfall, the land is of no value even for pasturage. The deadliness of these figures appears when one remembers that an Australian average rainfall of 15 inches may be made up of the following: 22, 18, 12, 8.

New South Wales possesses nearly half the sheep of Australia, while Queensland, farther north (half within the tropics) with more rain and heat and better forage, is therefore the leading cattle state since cattle stand heat and moisture better than sheep, and require better pasture. The market for the frozen beef of Queensland and frozen mutton of New South Wales, is almost entirely in the mother country, Great Britain. The wool is more widely distributed, but a large part of it also goes to the United Kingdom.

New Zealand. New Zealand, further south than Australia, with the good rainfall of the prevailing westerlies, is an excellent sheep country, and is largely given over to that industry.

Some of the mountain pastures upon the western coast of New Zealand, continuously wet from exposure to the sea winds, have such splendid grass that they will support five sheep per acre throughout the year. These mountains make the eastern side of that island drier, and thus cause the Canterbury plain on the east, the best stretch of arable land on the islands, to be largely used for wheat growing;[23] but owing to the sparse population, one and a half million people, in a good grazing territory as large as New York, New Jersey and Pennsylvania, agriculture cannot be very much developed, and the 32 million sheep and 4 million cattle are the chief wealth of the country. There are about 7,000 ranches of over 1,000 acres each, and the newness of the country is shown by the fact that between the years

[23] The likeness of this island to England is striking.

1891 and 1901 the occupied land increased from 20 to 27 million acres and reached 43 million in 1940. This is two-thirds of the total area. The good pasture and regular food supply of New Zealand causes its frozen mutton to be considered the best that is imported into the United Kingdom.[24] The sheep are often fattened by being turned into large fields of turnips from which they first eat the tops and then the entire root, and mutton can be produced at a cost so low that it sometimes competes in our own markets with American-grown mutton.

Argentina and Uruguay. These River Plate countries, as the English often call them, are important in the world of sheep. In Argentina, near the Paraná River, the rainfall is sufficient for the growth of corn, wheat, and flax, but as the distance from the river increases, the rainfall decreases, and, as in the region beyond the Missouri River, a corn belt is followed by a wheat belt and this by a zone of ranch lands in which the industrial future must, like the present and the past, be devoted to flocks. Seventy-five years ago, when there was a great demand for hair-cloth, herds of horses valued at $2.50 each were driven into pens twice a year to have their manes and tails clipped to furnish horse-hair for the crinoline looms in England and France. Then came the Merino sheep, whose wool and tallow, skin and bone also went to Europe, while his meat was thrown away because there was no possible market for it. Then came the refrigerator ship and the export of mutton. The pastures of the Paraná Valley are so fine that the sheep fatten entirely on grass. The sheep flock peak, 74 million, was reached in 1897. It is interesting that the present vast sheep flocks of Argentina are very largely owned and cared for by English and Scotch people, who for many generations in their own countries have been thoroughly acquainted with sheep and know their ills, their wants, and their ways. The cattle, requiring less care, are usually owned by the people of Spanish descent and cared for by the gaucho or half-breed cowboy of that country.

In northern Argentina, the greater heat and rainfall make cattle more important than sheep, and toward the cold south the plains of Patagonia, long a little known region, have been taken up as sheep ranges, often by young men of British stock from the Falkland Islands who are accustomed to sheep herding and to life on the cold plains. Sheep farms have been established on the far-away island of Terra del Fuego, at the extreme end of South America, the sheep being better able to live in this country than cattle since their wool protects them from the severity of the winter; they will scratch away the snow to get at the grass that lies beneath it, and, if necessary, they can fast for several days when the snow lies too deep.

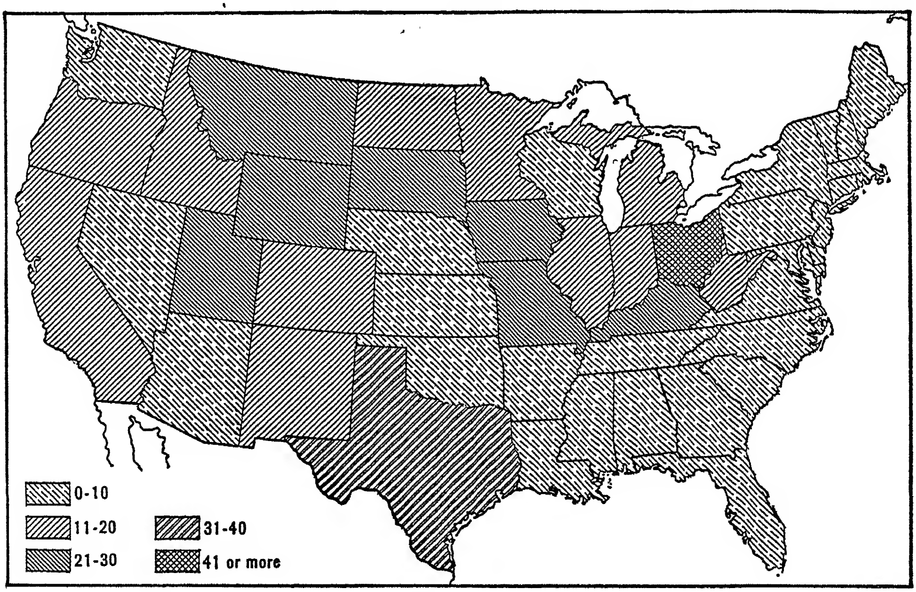
Uruguay, across the Paraná River from the best part of Argentina, is from end to end an undulating grassy plain. Twenty times as much land is devoted to sheep and cattle pasture as to grain-growing, and 95% of her exports consists of livestock and products. While the growing of wheat, corn and flax is increasing a little, Uruguay is likely to

[24] In 1939, the United Kingdom imported 958,000 cwt. of frozen beef and 3,752,000 cwt. of frozen lamb and mutton—all from the Southern Hemisphere.

remain a pastoral country for many years.

South Africa. South Africa is third among wool-exporting regions. Like Australia, this region has mountains near the ocean which shut off the southeast trade winds from the interior, leaving a moist plain near the sea for agriculture and cattle raising. Back of the mountains is a wide expanse of interior, much like southwestern United States, too dry for the plow, and with climate and the pasture conditions suited to sheep where not too dry for pasturage, as in the Kalahari Desert, which corresponds to the desert of Arizona. Wool has been one of the most important factors in the development of South Africa, and the number of sheep in the Union doubled in the first 20 years of this century and then remained fairly constant.

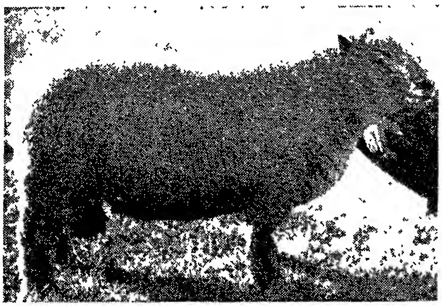
Western United States. The plains of the United States have not been at any time so exclusively devoted to sheep raising as have similar parts of Australia and Argentina, because the vigorous and hostile Indians held the American plains against the advance of the white man until the railroads came. Then cattle could be sent to market, and the sheep-growing and wool-exporting stage so common in the Southern Hemisphere was less necessary. The first industry of our West was the rounding up of cattle on the plains by the cowboy. Sheep herding came later and has had large development, especially in the mountain states and in Texas.[25] Outside of Texas sheep often roam on govern-



The relative numbers of sheep and lambs per square mile does not reflect relative importance of the sheep industry to the states in which they are. None of the five leading states, namely, Texas, Montana, Wyoming, California, and Utah, has the greatest number per square mile. Rainfall gives the answer.

[25] Sheep in millions in 1924 and 1944, respectively: Texas, 3.0, 10.2; Wyoming, 2.7, 3.3; Idaho, 2.4, 1.5; Utah, 2.4, 3.3; California, 2.4, 2.7; Montana, 2.3, 3.4; Colorado, 2.3, 3.0; New Mexico, 2.2, 2.0; Oregon, 1.9, 1.6.

ment land, an open, unfenced range where the grass belongs to any beast that eats it. The sheep eat it more closely than cattle do, leaving nothing behind them for the cattle, and often destroy the grass itself by pulling it up by the roots. A bitter animosity between the sheep owners and cattle owners has resulted, sometimes leading to fights involving loss of human life and the destruction of herds of sheep and cattle. The relation of sheep to irrigation and alfalfa is the same as that of cattle. (See section on cattle.)



A

These two sheep, visible at this point, show the result of artificial selection to obtain variation within a single species. This round watermelon is a champion Southdown ram, the breed that gets fat when it is six weeks old and stays so all its life, if it has half a chance.

Wool Sheep, Mutton Sheep, and Refrigeration. In the newer quarters of the world, where the object of sheep keeping is the production and sale of fine wool, the Merino is the best breed of sheep. By careful breeding and selection through many centuries it has been developed into a little bony animal, with a wrinkly skin, thereby furnishing for a minimum of food a little frame with a maximum amount of surface covered with a long, fine fleece which has at times been known to comprise with the grease 36% of the weight of the entire animal and have 60,000 fibers[26] per square inch of skin.

In the decade between 1880 and 1890, the perfection of cold storage and refrigeration suddenly caused a demand for mutton at Buenos Aires, at Wellington, New Zealand, at Melbourne and Sydney, Australia, as well as at Chicago, Kansas City, and Omaha. The rising price of meat since 1900 has emphasized that demand and made the carcass more valuable by far than the fleece. The Merino sheep, with his excellent fleece, had no plump fat carcass, while the mutton-loving English had carefully bred and selected the Lincolnshire and the Southdown and other breeds for the ability to grow large and fat and make fine mutton, regardless of their coarse and meager wool. The refrigerator ship suddenly made the big, fat sheep more valuable in Argentina, Montana, and Australia than was the little Merino

B

This amazing mass of wrinkly skin and bones is also a champion—Merino, specialized for wool. Sheep breeders could take a group of either one of these sheep and in time produce a duplicate of the other.

[26] The American Merino Type B has 16,000-23,000 fibers per square inch, while the Australian Merino has 61,000! Assuming an average of 12 square feet to one sheepskin, that would add up to 120 million fibers for an Australian Merino! No wonder it makes a fine soft cloth!

fare much better and produce a larger proportion of lambs than can be raised in the large flocks upon the range, where less attention is given them. It is a common practice of some Corn Belt farmers from southern Michigan to central Nebraska to buy carloads of lean lambs from the western range in the autumn, and fatten them on corn and hay for the winter market. Many of the eastern sheep owners make a specialty of rearing their lambs in the winter season and sending them to market early in the year when they command a very high price—"hot-house lambs."

There is a considerable area in the southern Appalachian highlands of Tennessee, Virginia, and West Virginia where ewes are grown and sold to the farmers of the Great Valley and the Piedmont sections of Virginia, Maryland, and also lower Pennsylvania.

New England, with its rocky and little-used farms, offers one of the best places in the United States for the extension of sheep growing. The rocky lands produce grass, and there might be worked out a combination of hill pasture and valley-grown winter forage such as exists in the arid West with its irrigated valleys. This would require the massing of several farms into one tract. At the present time about one-sixth of the sheep in the United States are east of the Mississippi River.

Sheep in Western Europe. The great increase of sheep in the Southern Hemisphere has helped local causes to produce a decline of sheep-keeping in most parts of Europe. Throughout western Europe the sheep industry resembles that of the eastern United States, and lambs and mutton are of more value than wool. The field in grain will produce more food than in sheep pasture, so that the grain field, the garden, the dairy farm and the sugar field have often taken the place of the sheep as the valuable wool can be imported more easily than the bulkier food products. Some fine mutton sheep, however, continue to be kept in the most intensely cultivated parts of Europe, as in Belgium, the Netherlands, France and Germany, but they are usually in the poorer, rougher, more scantily populated parts of these countries. Some of the European sheep are fed on barley and rape, a succulent cabbage-like plant that grows in sandy soil. In 1938 the Netherlands reported 654,000 sheep, while there were but 450,000 in New England, New York and New Jersey.

There has been less change in the sheep industry of Great Britain than in any other country of western Europe. The English had an early start at sheep keeping; they prize mutton and especially British mutton; their moist climate gives abundant grass; their low tariff policy makes easy the importation of grain, which is cultivated much less than on the nearby Continent, and in its place are sheep and cattle pastures. The chief British sheep districts are the highlands of north England and of Scotland and the eastern plain, where the Lincolnshire sheep has developed an unusual ability to survive on moist level land. Great Britain, with over 26.9 million sheep, about one-half as many sheep as people, has more sheep per 1,000 people than the United States, and in actual number about one-fourth as many as Australia, near thrice as many as France, 5½ times as many as Germany, but only one-third as many as Soviet Russia. In 1939, Russia reported

84.5 million sheep, coarse-wooled as are nearly all the sheep of Asia. Imported stock from Australia is expected to improve the wool. Much of Siberia and central Asia, like large areas of our West, is composed of thousands of miles of plains that are too dry for anything but pasturage.

One of the limitations of Russia is revealed by the sheep figures—1925-29, 130 million; then famine, and 47 million sheep remained in 1934. In 1939 the figure had risen to 84.5 million.

Sheep in the Mediterranean Basin and Southwest Asia. The Mediterranean climate, with its winter rain and dry summer, is very wholesome for sheep, especially if they can have mountain pastures. The Mediterranean countries and west Asia produce another region where sheep do well if the food be present. In this belt is Spain, with nearly 20 million sheep.

Sheep are very important in Greece, Albania, Yugoslavia, and Bulgaria—mountainous, isolated, primitive.

Sheep are very common and very important in semi-arid Asia Minor, Persia, Afghanistan, the mountainous parts of India, Tibet, Manchuria, and the interior dependencies of China. From all these countries there is an export to the western world of the coarse wool yielded by the hardy native sheep belonging to those careless Asiatic peoples who have never possessed themselves of the better breeds of western Europe.[27] Throughout this whole region from the Bosphorus to the Amur Valley the sheep live almost entirely by pasture, which is subject to the cruel uncertainties of climate; and despite the shifting of flocks from place to place, as described in the book of Genesis, disasters occasionally occur.

Sheep in Tropic Highlands. There is some sheep husbandry for local use throughout the mountainous regions of Mexico, Central America, and the Andean regions of South America. Mexico, with 4¼ millions, has more sheep than Canada, with 3.4, and Bolivia and Chile, with 5 million each, have more sheep than any five states east of the Mississippi River. In Ecuador, Peru and Bolivia, the Andean plateaus spread out in greater expanse and, with their rough surface, cool and semi-arid climate, are a good place for sheep, and there is an export of wool. It is true these countries are in the tropics, but the natives of the Bolivian plateau wear woolen masks to protect their faces from the biting blasts of the winds that sweep across the landscape 2½ to 3 miles above sea-level. Such a climate is the natural home of fleece-bearing animals, and in the llama, the vicuña, and the alpaca it has produced three with commercially important coats. Two of these animals, the llama and alpaca, furnish for export some very fine, long, soft wool, but the animals themselves have never appealed to the people of other countries as suitable for propagation.

With decline of sheep flocks in the old countries and the stationary conditions in the important new countries it is interesting to note the appearance of a possible new region in the highlands of East Africa. The British Colony of Kenya had 3.3 million sheep in 1938, the original stock being of the native woolless variety. Experiments at breeding up

[27] There are recent efforts made in Turkey, and Irak especially, to improve the breeds. In 1941-42, over one million head of sheep perished from drought in Turkey.

from these hardy sheep resulted as follows:

The sheep of the first cross shears 1½ pounds of wool.
The sheep of the second cross shears 3 pounds of wool.
The sheep of the third cross shears 4-5 pounds of wool.

The Goat. The goat, a producer of wool, zoologically a cousin of the sheep, is associated with him throughout the world; the chief factor of separation between the two being the goat's ability to survive a less hospitable environment and food supply. The goat's much jested ability to eat almost anything indicates that it is one of the hardiest of animals, capable of living under the most severe dietary conditions. Accordingly, where land is good and pastures are fat, goats are few; but where sheep can scarce subsist, the goat thrives on the browse of desert and mountain shrubbery. He fights enemies that kill the sheep or else scrambles to an inaccessible rocky pinnacle for safety. The semi-arid countries therefore greatly predominate in the possession of the world's 150 million goats. Spain has 7 million; Algeria, 3; Nigeria, 5; Union of South Africa, 6; and British India an enormous preponderance with 36 million. The result is that goat skins, which with sheep skins are so important in the leather supply of the world, come from the poorest pastures of the world. Many are exported from China, where they are brought by caravan from Mongolia and the central deserts of Asia. They come from the arid parts of India, from Persia, and from both edges of the Sahara. Most goats are of commercial value only through their skins, but in the district of Angora, Asia Minor, near Anatolia, has been developed the angora goat whose long, silky fleece, called mohair, competes with wool in making the finer fabrics. These animals have received favorable attention in the United States. Texas has 85%, or 4 million, of these beautiful little animals, and most of them are on the Edwards Plateau where a rare plant association causes sheep, goats, and cattle to occupy the same pastures. The goats eat leaves of trees as readily as grass, and they are utilized to some extent to destroy bushes and underbrush where it is desired to convert forests and thickets into cleared lands and pastures. This same browsing ability of the goat and camel has made them effective agents in the denudation and destruction of Mediterranean lands —one of the accomplished tragedies in man's relation to the earth.[28]

The Future Supply of Wool and Mutton. Unless we change our habits with regard to wool and mutton, the future supplies of these articles must be more extensive than that of the present time to keep up with increasing demand. Yet it is true that during the last quarter of the nineteenth century the world's sheep reached their maximum number under present conditions of production. As most of the new pasture plains have been fully occupied, increases of wool and mutton can only be made by improvements in the wool-yielding quality of the sheep themselves and by the greater intensity of agriculture which must cause a more skillful use of pastures and a greater and greater

[28] See reports of W. C. Lowdermilk, U. S. Soil Conservation Service, Washington, D. C.

portion of the world's sheep to be kept on farms in small flocks as they are in western Europe and eastern United States. This method, with costly land, barns and storing of winter food, is more expensive than that by which a single herder drives 2,000 or 3,000 sheep over a fenceless, barnless plain, costing little or nothing. Therefore rising prices for mutton and wool seem inevitable if demand increases.

9. *Draft Animals*

Our Dependence upon Beasts of Burden. Although man dominates the earth, he is physically weak in comparison to many other animals and has been able to possess the earth only by bringing their greater strength to his aid. The European discoverers found no draft animal whatever in the United States, a fact which goes far to explain the Indian's lack of complex technology. Without animals, he could not make the start from primitive economic status. Lacking animals to do his work and give him food, he was always so poor that he had to live from hand to mouth, and it was much harder to get the necessary surplus to give him the leisure to learn, accumulate, educate, and advance. It is not the Indian's fault that he had tamed no animal. We have tamed none except for pets.

Some draft animal seems necessary in the ascent of a people toward an elaborate technology, although in parts of Japan and China it has been shown that the animals can ultimately be reduced to a low minimum. Fortunately, while strong enough to work and intelligent enough to be trained, the animals are stupid enough to be ignorant of their powers and thus obey us.

Most of man's work has been done by ten animals—five of them of almost world-wide distribution, the horse, ox, ass, mule, and dog—and five of very special location—the camel, elephant, reindeer, yak, and llama. Our methods of using them vary according to the nature of the work, climate and roads, but our dependence upon them is so absolute that if they should suddenly disappear from the earth, western civilization and Oriental would be shaken to their foundations, and millions of men would probably starve. Despite all our improvements in machinery it is upon the muscles of trained animals that most of the human family still depends for the production of its food.

Group I. Draft Animals of General Distribution

I. The Horse. The horse, the aristocrat of draft animals, is second to the lowly ox in mass of work performed. He lives throughout the temperate zones except in the most extreme deserts, is only barred by the tropical forests and the snow-covered North, and even there he is of value, as shown by the surprising efficiency of Manchurian ponies in an English Antarctic expedition of 1908-09. Chiefly because of the attacks of insects, the horse does not do so well in the more humid parts of the tropic and subtropic regions as in dry climates where there is sufficient food. He is largely limited to the peoples of the Caucasian race. Thus the United States (10 million), Canada (3 million), Europe (22 million without U.S.S.R.), U.S.S.R. (17.5 million), India (2.5 mil-

lion). Compare these figures with India's 160 million cattle, largely oxen, and 45 million buffaloes, even more exclusively work animals; and we have convincing proof of the superiority of the bovine over the equine genus as tropic denizens.

For many centuries the Arabian horses, fed partly upon the barley of the oases, were supposed to be the best of all horses, but several importations of the best Arabian steeds throughout the nineteenth century have shown them to be inferior in speed, though rivals in strength and endurance to the breeds of western Europe. Partly Arabic in their origin, the European horses have for several hundred years been bred with greater care in the selection of only the best parents for each new generation, with the result that the horse of the West now surpasses his distant cousins in the old home in Asia. The English especially are great lovers of the horse and of the horse race, and where two or three of them are gathered together in some Far Eastern corner, behold there is the Jockey Club in the midst of them. For several hundred years the British have been the leaders in the improvement of the breeds.

The Types of Horses. There are two general types of horses. First, the heavy draft horse to draw heavy loads. This class originated in the good agricultural lands of west Europe. The second class is the thoroughbred or running horse, a product of England's race courses. A third class, the driving horse, is now rapidly becoming extinct because of the automobile.

As an industry, the production of horses for sale is always carried on in regions that are good for the production of cattle, because both animals have the same physical and climatic wants.

The Breeds and Growing of Horses in Europe. In northwestern Europe many horses are raised, but, as with cattle and sheep, their number is insufficient to meet the needs of the people. Britain has two heavy draft breeds, called the Shire and the Clydesdale. There is a Belgian breed of heavy draft horses and the north of France produces many horses of the Belgian breed and also the Percheron named from the French department De Perche. This breed, owing to an infusion of Arabian blood, is the quickest of the heavy draft animals, and was long used to draw the omnibuses on the streets of Paris, but in 1913 was finally replaced by the automobile. The Percheron is the leading draft horse in America.

The American Horse Industry. Horses of the European breeds early made their escape from the Spanish settlements in Mexico and ran wild on the western plains and mountains for three centuries until, with the buffalo, they almost vanished before the American settler in the last quarter of the nineteenth century. These wild or half-wild horses, usually called bronchos, Indian ponies or cayuses, had degenerated in size but had developed wonderful endurance. After the first settlement of the Plains, they ran on the range and were cared for like range cattle, being caught up at intervals, branded, and sold when ready for the market. Like the wild cattle, this breed has now almost disappeared through admixture with the European breeds brought from the eastern states.

One of the best-known centers of American horse production is the blue

grass region of central Kentucky, with the city of Lexington as its center. This plain of eight or ten thousand square miles is underlaid by a bed of limestone which upon exposure to the air breaks up into a soil of great fertility and one in which blue grass grows to perfection. This is one of the best of pasture grasses, especially for horses. The race horse is still one of the money crops of this region. Trotting and saddle horses are the chief kinds, and, despite our present-day preference for automobiles, horses from the Lexington district are still to be seen prancing through our city parks.

There are occasional horse ranches on the Great Plains of the United States from Canada to Mexico, whence horses are sent to the mining and timber camps of the mountains.

In the United States, the horse has been almost pushed off the roads and into the fields—chiefly to the hillier fields. In April, 1944, a drive of 170 miles southwest from Chicago revealed hundreds of farmers fitting their fields —but not one horse was seen.

The decline in horse and mule number coincides with the expansion and development of tractors, automobiles, trucks, and other mechanized machinery. An average of more than 100,000 farm tractors a year has been sold since 1918 in the United States. In the five-year period, 1936-40, this number was nearly 200,000 a year. The number of automobiles and trucks in operation on farms and in cities increased from 9 million in 1920 to 32 million in 1940. The number of horses in the United States has declined since 1915 from the all-time high of 21 million to slightly over 9 million in 1944, but in Europe they almost held their own between 1913 and 1940. In South America, they increased a bit; and in Asia, outside U.S.S.R., they increased from 10.6 to 14.8 million. In the United States and Canada, the beasts of burden seem destined for still further decline, because of the use of smaller power units that replace one or two horses at the cultivator, etc.

The Pony. Where the horse has been long in regions of scanty food supply, he has degenerated in size. Ponies have been thus produced, the breeds usually bearing the name of the region of origin—Russian, Manchurian, Welsh, Iceland, Orkney, Shetland, Zacetecas, and many of them show pronounced adaptation to their environment. The slow, strong, short-legged Shetland pony with his block of a body, his veritable overcoat of mane and tail, and his oily thatch roof of a coat has been produced by the humid, raw and cold climate on the heather-clad hills of Shetland near the latitude of southern Greenland. Grant them pasture, hay, and a shed in Iowa, and they increase in height 10% in a generation.

II and III. The Mule and the Donkey or Ass. The mule, which has a donkey for a father and a horse for a mother, is in some respects a better draft animal than either parent. It is so extremely hybrid that it is sterile, "without pride of ancestry or hope of posterity." The donkey is conspicuous among the common draft animals because of its extreme hardiness, longevity, and ability to thrive like a goat upon rough food and under poor conditions. It has larger bones and greater strength than a horse of similar size. The burdens borne by the Asiatic donkey are an almost unbelievable amaze-

ment. The wild ass is still found in the most desolate parts of Mongolia and Turkestan, where his fleetness and hardiness enable him to survive even in the home of the wild camel.[29] From this parent the mule inherits long life, a hard small hoof, sure-footedness, and the ability to thrive on little food, in all of which respects it excels the horse, from which it inherits size and spirit.

The Distribution of Donkeys and Mules. The mule and the donkey (especially the donkey) prevail where conditions of life are hard. Thus China, Turkey and India have two-thirds of the donkeys of the world, and Spain, Italy, Egypt and Morocco have a fourth. The north of France, with its rich pastures, produces the fine, fat Percherons. But southern France, with the drier climate of the Mediterranean, has poorer pastures, and here mules and donkeys are bred. Spain has half the mules of Europe, and from its arid plateaus exports to all the world the finest asses to be used in the breeding of mules. Spanish horses are but one-fourth as numerous as the donkeys and mules. Throughout the desert region from Morocco to Peiping the mule and the donkey climb the hills, thread the mountain passes, browse on the arid plains in companionship with the camel, which braves the worst desert, the ox that draws the creaking cart, and the horse that bears the proud chieftain.

The ability of the mule to stand greater hardship and a more humid climate than the horse has made him the favorite in the tropics and the southern part of the United States. The cotton cultivator is still largely mule-drawn. The southern states have one-fourth more mules than horses. The north central states eleven times as many mules as horses. The mule often stays but two or three years in the state of his origin in the north central states, and then plows cotton for twenty years.

The American Mule Industry. The finest mules in the United States are grown in the horse belt of Kentucky and adjacent districts of Tennessee, where the mothers are the culls of the fast horse breed. Missouri is probably the greatest mule-producing region of the United States, and St. Louis is the greatest mule market.

IV. The Ox. In almost all cattle-keeping countries oxen are used, to a slight extent at least, as work animals, but not so much as in past periods, because of the competition of the more efficient horses, mules, and donkeys. Among the peasants of northwestern Europe and many other lands, even the cow that supplies the family with milk is at times harnessed to the wagon to help with the farm labor. In the Far East the cow is elected as worker because she bringeth forth increase. Although very slow, the ox is unquestionably stronger than the horse, and, deep in the mud of a swamp, will pull where a horse would not even make a try. Consequently, their present limited use in the United States is to haul logs in the lumber operations of Appalachia. They are also still used a little on the rocky lands of New England. In the muddy sugar-cane fields of Cuba and on the very bad roads in parts of tropic America the ox-drawn

[29] The Roy Chapman Andrews expedition to Central Asia in 1924 caught a four days' old infant ass. His almost unbelievable achievements at kicking indicate that the mule comes honestly by his most famous characteristic.

cart is generally used because it is the best wheeled equipment for the special conditions, which often resemble those of the morass or lumber camp. The ox will also stand more abuse without injury than the horse will. In the main, the ox is the work beast of poverty.

Oxen and Agriculture. The general use of oxen in agricultural labor is usually an indication of an industrially backward people who are willing to content themselves with slow helpers or who must take advantage of the factor of cheapness arising from the fact that the ox can eventually be sold as a beef animal.[30] Such a combination of oxen and backward agriculture we find among peoples of southern and eastern Europe, and in places throughout central Asia to Peiping and Manchuria it is probable that there are as many oxen used as in all the rest of the world. Hundreds of millions of people there use almost no other beast of burden. As cattle can survive the tormenting tropical insects better than horses or even mules, oxen are probably the most used agricultural work animal of the tropics. On the muddy roads and muddy rice fields of the Philippines and southeastern Asia the carabao or water buffalo, an economic duplicate and a zoologic cousin of the ox, is used as an ox and is the prevalent beast of burden, although his slowness probably makes him the least efficient of all the larger draft animals. India, with 160 million cattle and 45 million buffaloes, almost certainly uses more oxen than all the rest of the world. Hundreds of millions of people there use no other beast of burden.

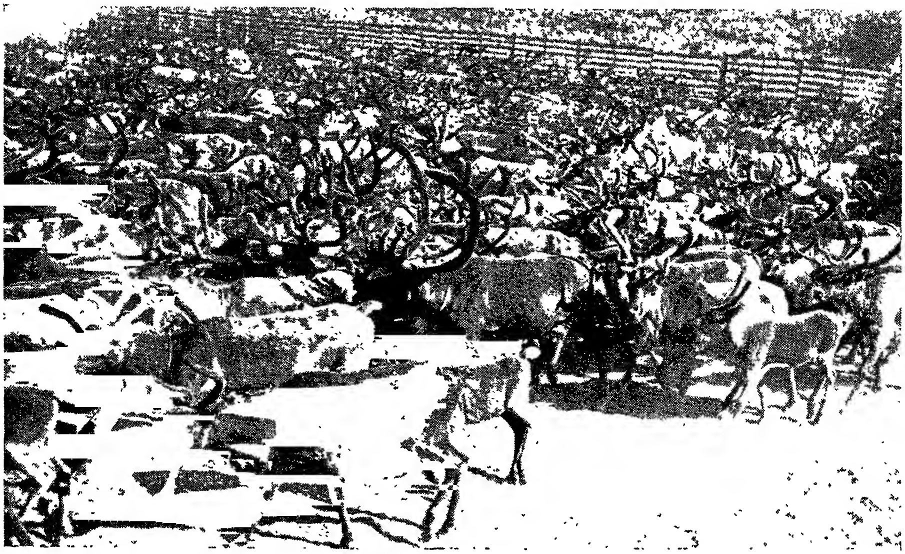
V. The Dog. Least important of the general draft animals is the dog, rival to man in his ability to live in all climates. In Alaska alone 18,000 work dogs were reported in 1920, and 24,436 in 1939! He does the same service in some of the colder parts of Europe and Asia, but it is probable that the dog is most used in the densely peopled agricultural regions of northwestern Europe to pull small carts.

Group 2. The Draft Animals of Special Location

The five draft animals of special location are generally inferior to the horse and the mule, but have some peculiar adaptation to environment that enables them to work in places or services where the horse and mule are less efficient, if they can survive at all.

I. The Reindeer. The reindeer is a specialist at surviving cold and a poor diet, such as Arctic shrubs, scanty grass and the moss which grows on otherwise bare ground of the almost continually frozen Arctic plains, called tundras. Over this bleak, treeless, and uninviting Arctic region the caribou and other species of the reindeer family are widely distributed. A Chinese traveler in the fifth century A.D. reported the domestication and use of the reindeer in the Eurasian Northland. It is used chiefly as sled animal from Lapland to Kamchatka. The reindeer are essential to the life of many of these people, for in addition to acting as beasts of burden, they furnish milk, skins, and meat to the herdsmen, who count them as their sole

[30] "You see, Señor, it is this way," said the manager of a Portuguese estate in defending his use of ox teams rather than the more speedy mules. "The ox eats straw, while the horses and mules need some grain, and then—" he paused a moment—"and then we eat the ox."



A

This herd of reindeer in Alaska shows one of the phases of the attempt of the European man to transfer to North America an old Asiatic livestock industry.

B

A part of the attempt of the Europeans in Alaska to teach the natives the ancient reindeer arts of north Europe and Asia. This fence of burlap serves to hold the reindeer in place as effectively as solid boards. It appears that the reindeer is almost as easily fooled as people are. Which of us is not held by some flimsy filament?

wealth. In 1891 reindeer were successfully introduced into Alaska, a country similar to their own; the herds have since that time increased, and the Canadian Government has made a start.

But clouds have arisen to obscure the future of the industry. Cloud one, the wolf. Cloud two, the Eskimo and the Indian are accustomed to working furiously, and then resting completely. He who keepeth reindeer sleepeth with one eye open. Cloud three—scarcity economics working in the form of the cattle lobby to keep the good reindeer meat out of the United States market. Santa Claus travels through the streets of

Nome, Alaska, with real reindeer drawing his sleigh.

II. The Yak. The yak, a close cousin to the ox and the buffalo, is a native of the Himalaya Mountain regions and is adapted to high elevations and scanty food, but especially to deep snow. The under parts of his body have long thick hair reaching nearly to the ground, so that he can lie on this natural mattress with warmth and comfort on the deep snows of high mountains. This animal is at present used only in Tibet and the adjacent high regions of central Asia, where he draws carts and carries burdens on his back. The naturalist, Mr. Thompson Seton, has pointed out that large areas of Canada, not well suited to ordinary cattle, might well be given over to yak pasturage.

III. The Llama. The llama is the only American animal that man has been able to put to work. It is interesting to note that he served the Inca civilization, a culture whose achievements have been insufficiently appreciated. The llama does for the Andean Highlands of Peru and Bolivia the service rendered by the yak in the Himalayas. The llama is a small animal resembling both the sheep and the camel, and is used only for carrying packs which cannot exceed a hundred pounds in weight. He does not have great amounts of snow to contend with, but for sure-footedness in climbing the exceedingly precipitous Andean heights, the llama has no superior, especially as he can pick his living from a very unpromising wayside as he goes.

IV. The Camel. The camel is well known as a specialist in the ability to survive in comfort and carry a burden for several days without food or water and to live upon the harsh vegetation of the desert. For many centuries this animal has been distributed from the western Sahara through Africa and central Asia to eastern Mongolia, and has lately been introduced into the Australian desert. There are two kinds, the one-humped and the two-humped or Bactrian camel. This latter is found all the way from the Crimea in south Russia to Peiping, and from the trans-Siberian railroad to northern India, where it crosses the territory of the yak. Without the camel many parts of the desert region of Asia and Africa could not be inhabited, and many deserts over which caravans have passed for ages could not be crossed. The largest heavy draft camel can slowly carry a pack of from 700 to 1,000 pounds, the fastest saddle animals can take a man a hundred miles a day; and they can carry these burdens for several days, living the while upon the accumulated fat which has been stored in the humps upon their backs. This storage of energy in the camel's hump is like that accumulated by the pig and the bear in autumn to enable them to lie for days contentedly in their beds when the winter season makes hunting for food difficult. The fat-tailed sheep (tails of varied shapes), the fat-rumped sheep, and the fat-backed sheep of various Old World deserts rival the camel and the pig in fat storage. The camel, unlike the others, uses his surplus to carry him over a hard region rather than a hard season.

V. The Elephant. Elephants have a restricted field of usefulness, since they live only in the tropical forest regions of Asia and Africa. They will not breed in captivity. Only Asiatics have been energetic enough to catch and domesticate them in modern times, but the Car-

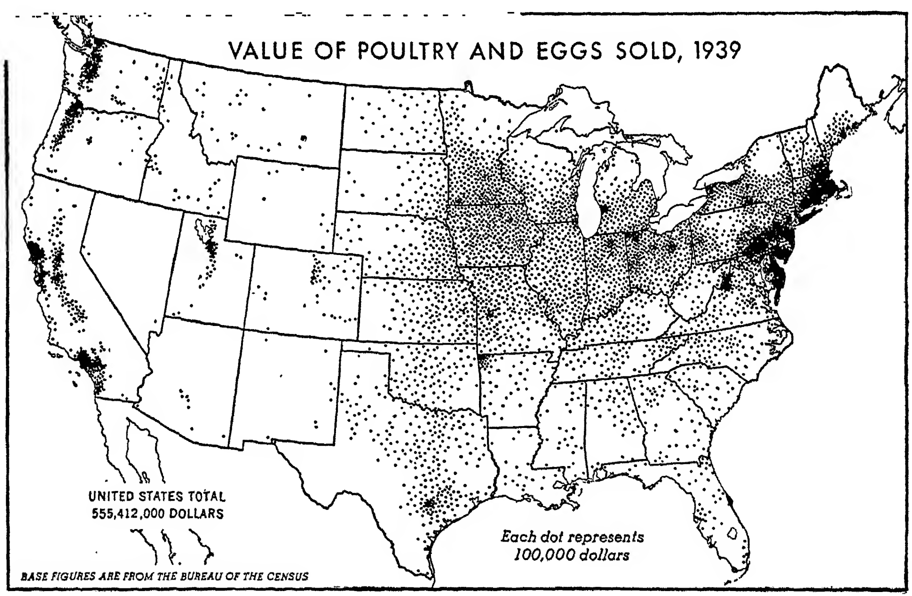
thaginians used them in Italy. They draw plows and wagons and carry passengers on their backs, but are most useful in lumber yards where with great skill and dexterity these live cranes lift and pile logs which a dozen men would have difficulty in handling.

10. Poultry and Small Animal Industries

If you say something about gold, silver, or wheat in an assembly of business men, they pay respectful attention. Say "hens," and they grin.

Yet, in 1943, the two and two-third billion dollars derived from chickens and eggs in the United States exceeded the value of our production of silver, gold, and wheat combined.

The small attention and scant respect given to the lowly hen are due in part to the fact that she never gets on the stock ticker, doesn't lend herself to large speculations, or to trusts and underwriting operations. And everyone knows or knows of the person who set out to make a fortune in the chicken business, plunged, and failed. The investment banker, as an investment bringer, knows not the hen. Therefore, poultry is neglected for these reasons. Further, legislation does not have much to do with it, and it plays a small part in international trade. Poultry keeping is none the less important and is undoubtedly the most universal form of animal industry in the United States and also in Europe, east Asia, and other foreign countries. The names of breeds attest their world-



This agricultural industry is less dependent upon the particular quality of the land upon which it rests than any other. Note its density in rocky New England. The poultry industry resembles fruit and truck industries in its dependence upon centers which develop market facilities. The concentrations of poultry production areas in spots, such as the one in Virginia, and several in the Corn Belt, are in places that have no advantage over other places nearby, except that of having got an earlier start.

wide distribution—Pekin and Muscovy ducks; Cochin, Brahma, Leghorn, Hamburg, Minorca, Indian Game, Wyandotte and Plymouth Rock chickens; Brabant geese.

Fowls are kept in villages as well as on 85% of the farms throughout the United States. They are usually a kind of by-product, often a perquisite of the farmer's wife. The very large majority of the fowls in this country are found in comparatively small numbers (about 60 per farm), on more than four million farms, where they gather much of their own subsistence, and receive little care. The consequence is that the eggs are produced at little cost, though their value is the astounding total of a billion and a half of dollars in 1943.

The poultry industry spurted during World War II, as no other animal industry could spurt because of the physiological facts of reproduction. The Machine Age has come to the poultryman, and with a little help from man, a hen may now easily have a hundred children in a year. The farmer's wife still places some eggs for hatching in the overturned barrel in the barn, but look at the scientific hennery, where one person operates 30,000 eggs in a mechanical incubator. It works on a very large scale, and is as successful as the hen, who is now free to devote her whole time to the production of eggs. The brooder, a successful mechanical mother, has been achieved and completes the necessary equipment for large-scale production.

Poultry keeping is equally well fitted to be a by-product in extensive agriculture or a main product in intensive agriculture with a strong tendency to be important where agriculture tends to be intensive and near cities. Half of the poultry in the United States is in the Corn Belt and around its margin where feed is cheap. There are two notable districts of poultry specialization. Six counties in southeastern Pennsylvania had over 5 million poultry in 1920, or more than 4,000 to the square mile. Intensive poultry raising crops out still more sharply in California with her high land values. Sonoma County, where Petaluma is the poultry center, had 3 million poultry and led the country in eggs in 1939, while Los Angeles County was second largest egg producer.

Meanwhile Sussex County, Delaware, has shot forward to first place in number of chickens grown—16 million of them in 1939—a new style, the commercial broiler, standardized at two to four pounds. We had 85 million of them in 1934, 337 million in 1940, 619 million in 1944—and a quarter of them in this one Delaware County, and nearly as many more in adjacent counties in the peninsula between the Chesapeake Bay and the Atlantic Ocean, often called Delmarva.

Poultry probably reach their greatest relative importance in China. There, ducks and geese and chickens can serve as scavengers and save every last speck of digestible material from being wasted, and Chinese patience cares for the birds.

Years ago, the low cash wages that are often mentioned in connection with China were partly explained by the fact that in the interior of that country, eggs were two cents a dozen. This price helps to explain the early development by the Chinese of an export of dried eggs. The Chinese dried egg has been a staple of commerce for years. Factories on the Shantung peninsula and elsewhere convert millions of dozens

yearly into dried eggs, dried yolks, and albumen (white of egg). By this means 1,000 eggs can be reduced to 22 pounds' weight, easily transported and said to keep indefinitely.

Dried eggs sprang into great importance in the United States during World War II for soldier food, and probably many a G.I. has announced that he will never eat another scrambled egg.

The greatest peacetime commerce in eggs and, with the possible exception of China, the greatest production, is in Europe. Great Britain imports far more eggs than all the rest of the world combined, 425 million dozen in 1938. Denmark was the chief supplier, but they came from Italy and nearly all parts of western Europe. They were exported from Russia and Siberia before World War I. The European peasant farmer finds it more necessary to sell eggs than does the American with more land, but we are tending rapidly in that direction, as shown by our great poultry increase. However, we can scarcely be said to have reached the export point—4.5 million dozen in 1940. It is a perilous venture to open, at the breakfast table, an egg of uncertain ancestry. For the breakfast egg, like Caesar's wife, must be above suspicion. Denmark has taught the world how this is done. Each farmer belongs to a cooperative association. Each egg has stamped on it the number of the association, and the number of the farmer. Therefore, the British householder who breaks a bad egg can send the record straight back to Hans the Hen-Grower in any corner of Denmark, and the bad egg costs him $1.38 fine. The second bad egg costs him still more, and the third is worse than three strikes at baseball, for he loses his membership in the egg association. With such attention given to the satisfaction of the customer, it is no wonder that the Danish egg has become a prime favorite in England, which takes the largest share of the output. American farmers have taken a leaf from the Danish book. Many of our commercial eggs are now sold through cooperatives. One Pennsylvania egg cooperative increased its business in ten years from $10,000 to $3 million. The process—every farmer's eggs are inspected, graded, and weighed, so that the buyer can know what he is getting. Owing to the high value of output in proportion to food, it should be emphasized that the distribution of the poultry industry depends more on man and less on the environment than any other of the animal industries thus far discussed. It should also be noted that in its large-scale prosecution the failures in the past have far outnumbered the successes, because of the unusual amount of detail involved.

Turkeys, ducks, and geese comprise about 8% of the poultry of America, but despite the feathers of the ducks and geese, these birds, because of their small number of eggs, lack the double source of income furnished by the chicken. In Germany the tractable and thoroughly domesticated goose is esteemed as the untractable and not thoroughly domesticated turkey is in America, and it is common to see boys herding them in large flocks at pasture.

The rearing of rabbits and hares is, in its economic aspects, close kin to the poultry industry. Hares have the advantage of being able to thrive in closer confinement than poultry, and they will feed on a very wide range of vegetable

food—weeds as well as hay and grains. They are quite generally kept by the small farmers of northern France and Belgium, whence they are exported to England by the hundreds of tons. Relief workers helping to restore devastated France had a regular practice of giving to the repatriated peasant among other things a cock and two hens and a pair of hares.

In ostrich farming we have an interesting example of a new domestic ani mal and a new industry.[31] This feather-producing bird is a native of semi-arid Africa, being found over most of the Sudan and large areas in South Africa. The British in South Africa are the real founders of the ostrich industry, having discovered that when enclosed by a strong fence and supplied with suitable food of grain and good grass the ostrich will thrive about as well in domestication as the sheep. This is an industry capable of great extension, but who wants ostrich plumes? and how many?

Bee keeping, with its products of honey and wax, preys upon the blind thrift of an insect. Like poultry it depends (as an industry) to an important extent upon the human element, but it also must have an environment affording nectar-bearing flowers. Where rainfall permits abundant vegetation, the tropics are the best bee lands, especially as many tropic forest trees are nectar bearers. Honey and wax are important exports from the Greater Antilles, and there seems to be plenty of room for extension of the industry. Bees are among the most highly developed of animals.[32] Their care is, if well done, one of the most scientific of the animal industries. A small amount of bee keeping is common in nearly all the warmer parts of the United States and Europe, but it is a by-product industry which, owing to its dependence upon a very minor product of blooming plants, cannot be intensified. There was a marked decline in the United States 1929-39.

The rearing of song birds is an interesting avocation that might in its economic side be considered as a sort of miniature poultry industry—the artisan's poultry as compared to the farmer's poultry. The canary bird is the most important of these birds,[33] and the Harz mountain region of Germany, where there is a dense industrial population in a mountainous district, was for years the greatest center of production. These people are well educated, but receive low wages, and the rearing of song birds is carried on at small expense in the home. The house climate lets this native of the warm Canary Islands live in lands of frost. The keeping of cage birds is a custom world-wide, and of unknown age, but large traffic in the birds has arisen only since the coming

[31] It is astonishing and it should be humiliating that we who boast so much of our one and only civilization should have inherited from the prehistoric ancestors the domesticated horse, cow, sheep, goat, chicken (Indian), turkey (American Indian), duck, goose, reindeer, camel, dog, and have ourselves thus far added nothing to the list save the plume-bearing ostrich, and have let the African elephant run wild where he now faces extinction through the merciless trapping of the ivory hunter.

We have recently started in on fur farming. We have confined several species—fox, skunk, muskrat, mink—but none of them, like the ostrich, has as yet been domesticated in the sense that like all of our other animals it will stay about our abode and consider itself a part of the place.

[32] The elaborate social order which prevails among the bees even to the extent of a physiological adaptation thereto is astounding when compared to man's crude efforts.

[33] Like the hen and the cow, the canary has now many recognized breeds.

of fast transportation by steamships. The United States has usually imported about 200,000 per year—German, Belgian, Dutch, British, and in 1940 a third of them from Japan. The more abundant relation of people to resources in the United States is well attested by the practical absence of commercial bird raising in a country where they are bought by hundreds of thousands, and almost any home is a suitable place to breed them.

Fisheries

Fish and the Conservation Idea. Proverbs tell something about the land where they originate. An early conservationist made a remark about killing the goose that laid the golden egg. The author of that adage was a landsman. If he had lived on an American fishing coast, he could have made much more forceful illustration of his vital message by talking about fish. We Americans who boast so loudly in big figures and pat ourselves on the chest so resonantly the while, have given little thought to the golden eggs on the spawning bank.

Twenty years ago, the Secretary of Commerce reported: "The oyster fisheries of Chesapeake Bay have decreased to 50% in twenty years. Our lobster catch is less than one-third that of thirty years ago. Our great supplies of salmon on the Atlantic coast have totally disappeared. They have been diminishing over one-half on the Pacific coast.

"The sturgeon fisheries of the Great Lakes have declined 98% in forty years. . . .

"Blindly, without regard to the stability of the industry in our generation, without sense of responsibility to future generations, we are recklessly destroying our littoral fisheries—that is, the species of sea-food in our bays and adjacent to our coast, at a rate which promises the end in a generation unless we accomplish further reform. (How can we prove our superiority to the cow that tramples most of her hay into the mud?)

"One great enemy of our fisheries is pollution of the water. Pollution comes from a hundred different sources. Ships, factories, coal-mines, chemical works, cities and towns—to mention only a few—all make their contributions of waste and refuse in the waters. Most of these forms of pollution damage fish. Some of them are enormous in their damage."

The shad, like the salmon and some other fish, live in the sea except for one run up a river to spawn. In 1889, the catch of shad in the Hudson River was 4 million pounds. In 1916, it was 40,000 pounds, a decline of 99%, and the business was so bad that fishing practically ceased. Nature had a chance to restore. Therefore, the catch of 1941 was 2.7 million pounds.

The fish are like many of the other resources upon which our mechanical civilization depends, limited in amount and rapidly declining. They are unlike many in that they offer hope of restoration, the cycle being as follows: natural plenty, destruction by man, study of the situation, restoration by the application of science, and the control of this generation in the interest of the future. Unfortunately the latter two stages require intelligence and the concept of racial welfare, the former of which is but slightly visible in larger human affairs

and the latter almost completely invisible.

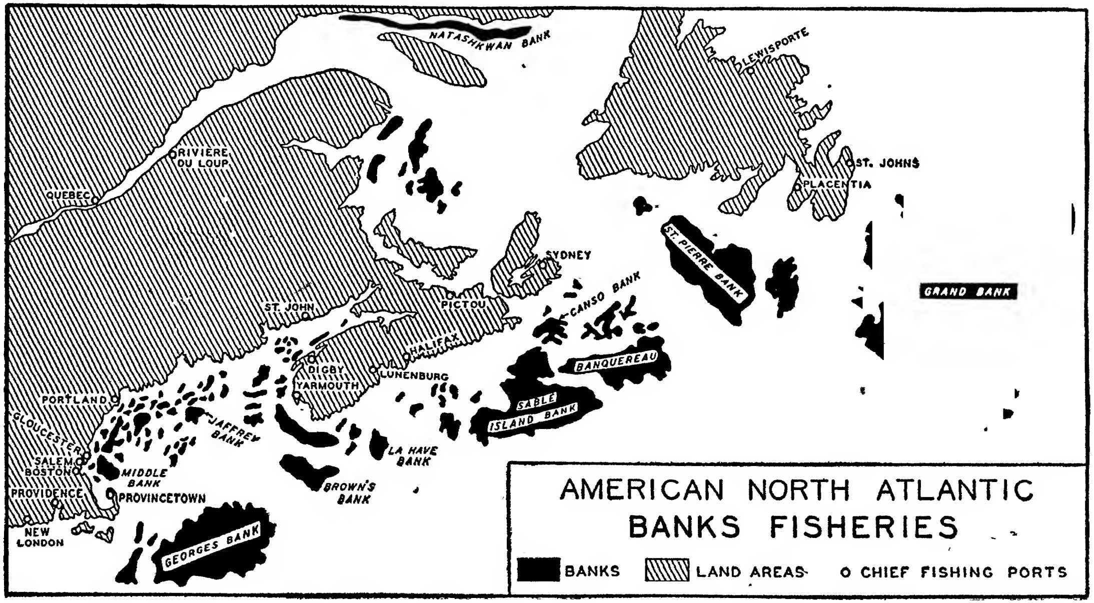
Fish and Marine Plants. The sea is a great resource, but little used as yet. It covers three-fourths of the world's surface. Even the clear water of the sea has countless millions of minute plant organisms which are eaten by many small animal organisms, they in turn are eaten by each other and by the smaller fish, and they in turn by the larger fish, but the support of the whole pyramid of marine animal life, like the life of land animals, is based upon vegetation, mostly microscopic, called plankton.

The word fishery is applied to the catching of practically any animal that is taken in the water, as oysters, lobsters, whales, and even seals, which are often taken on shore. The word fishery also refers to the place where fish are caught.

Relation of Fisheries to Seafaring. Fishing is our most ancient industry—the only important economic survivor of the hunting stage of human existence. Sea fishery is considered the cause that first led man to sail upon the ocean, and from this beginning, all maritime nations have had their rise. Such was the origin of the fleets of the Phoenicians and the Greeks who laid the foundations of Italian cities. The Norsemen on the inhospitable shores of Scandinavia developed fleets where man must fish or starve. The Dutchmen who wrested the commercial supremacy of the world seas from the Portuguese had had centuries of maritime training on the herring banks of the North Sea. In recognition of the importance of fisheries to Dutch welfare there was each year for centuries a national celebration in which one of the most important ceremonies was the public eating of a salt herring by the Dutch ruler. The fleets of England had their origin on these same fishing banks of the North Sea, and later the New Englanders became the pioneer seamen of America because good fishing banks were near them. The schooner, the fastest of all sailing vessels, was invented and it was used by the fishermen of New England until the steam trawler revolutionized the industry in the second quarter of the century. In recognition of the importance of the sea industry to Massachusetts, a dried codfish has, since colonial days, hung in front of the desk occupied by the speaker of the Massachusetts senate.

The fishing industry, through its connection with sea power and the romance and charm of the ocean, tends to be overestimated in its real importance. All the fish that are caught by Americans annually (worth about $117 million to the fishermen) are worth but a fraction of the eggs from the American hens' nests. The annual fish catch of all the world has but a fraction of the value of the poultry and eggs of the United States.

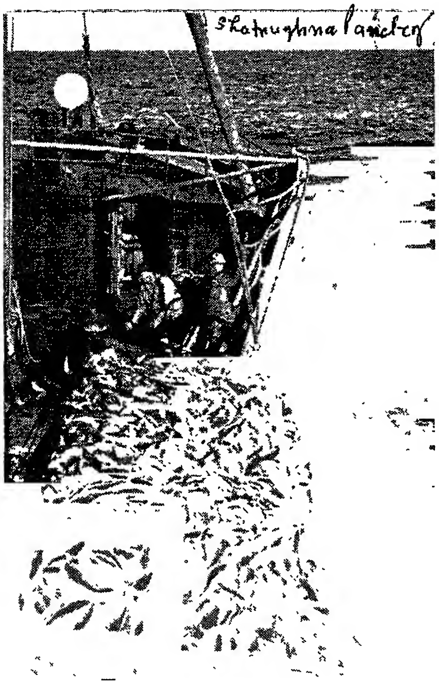
The Locating Factor of Fisheries. Most of the world's fishing industry depends upon two habits of fish which enable us to catch near the land those that may have passed most of their lives hundreds of miles away at sea. The first is the spawning habit of many species which lay their eggs only in rivers or in the shallow waters near the shore. The second is the congregation of fish to feed upon the bottoms, in shallow waters, commonly called "banks." The occurrence of such banks near the shores of northeastern Asia, northeastern North America, and northwestern



School grounds—schools of fish and schools for fishermen. There is no record of the time that Europeans began to fish these Banks. It was before the days of Columbus, despite the fact that they are in one of the roughest of the world's oceans.

Europe is responsible for the three greatest fishing regions.

North Atlantic Fisheries of America. The fisheries of northeastern North America are based on a rich combination of rivers, bays and shallow off-shore



The Machine Age goes to sea. A steam trawler has dragged its great metallic scoop along the bottom of the shallow sea, hoisted it by engine power and dumped its load of fish upon the deck of the boat.

banks. Especially important are the Grand Banks of Newfoundland and smaller banks off Labrador, New England and New Jersey. The Newfoundland banks were known to the fishermen of Europe and were regularly visited before Columbus made his epochal voyage. In that day the fishing industry was relatively more important than at the present time. Practically the whole of Europe was Catholic, and even to those who could afford meat there were many fast days upon which fish must be eaten in place of meat. Scores of vessels sailed back and forth from France to these Newfoundland banks each year for a century before the French made settlements in the St. Lawrence valley. This is clear proof that the fish and not the land were the important things about the new continent for several generations.

For four centuries men risked their lives on the Grand Banks by fishing with hand lines from row boats mothered by a schooner. All this has been changed by new inventions—the steam trawler (boat) and the trawl. This latter device consists of a bag-shaped net, which is drawn over the ocean floor behind a power-driven vessel and scoops up the fish as it moves forward. By its use a smaller number of men can catch a larger quantity of fish in a shorter length of time. The first was introduced in 1905. By 1938 they had increased to 250, accounted for 81% of the catch in New England.

Proximity to the banks has made fishing a leading New England industry since Colonial times. Massachusetts and Maine have the most important fisheries, and Gloucester, Mass., was for a long time the greatest fish port in America; nearly the whole population being engaged in preparing to catch, catching, curing, buying and selling of fish. Boston surpassed Gloucester and held the lead for 35 years and recently lost the lead. Gloucester again leads, and Portland, Me., runs third.

The revolution in fish catching has been matched by revolutions in fish marketing. Not long ago Pittsburgh was about the limit to which a barrel of

New England fish, with ice, could be shipped. Enter the filet, a portion of fish cut off, freed of bones, packed in cartons, frozen hard, and sent in refrigerator cars to Denver or San Francisco. This wakes up a drowsy industry. Gloucester booms again, and the rose fish, scorned for centuries because it has three-quarter waste, now becomes number one fish because it has two nice filets and a lot of refuse to make fish meal (stock feed and fertilizer), glue, and fish oil for casting aluminum, lubrication, tanning leather, making paint, varnish, insect sprays, and printing ink.

Prior to the meteoric rise of this rose fish the haddock had had 20 years of leadership over the historic cod, champion of 400 years, now trailing at third place. The cod is at its best in cold waters and is taken in greater quantity by the Canadians than by the New Englanders, and the people of Newfoundland and Labrador catch more codfish than all the rest of the people of America. Dried cod makes nearly two-thirds of the exports of this northern dependency of Great Britain.

Newfoundland and Labrador offer one of the best modern examples of a people living from one resource—so great is their dependence upon fish. There is some iron mining and paper making, but three-fourths of the workers are busy with fish.

The climate is so cold and damp that there is but little agriculture, a garden even being a rarity in Newfoundland. The people who are not at sea catching cod, or herring, are busy curing them. Some of the cod are sold fresh, but most of them are cleaned and salted as soon as they are dumped from the trawl, and when the boat reaches its port they are dried in the sun upon sheds which stretch conspicuously along the coasts. The herring is salted or cured by smoking over a slow fire after being salted.

The Nova Scotia fishing industry with a catch of $13 million per year, almost equals that of Massachusetts, the leading state of the United States, and the total Canadian catch ($62 million in 1941) was thrice that of New England. Nova Scotia with her many good harbors partakes somewhat of the character of Newfoundland but, though she catches nearly one-fifth of the fish of Canada, the warmer climate of this province enables her people to engage, to a considerable extent, in agriculture, and they ship sheep, cattle, and horses across the straits to the people of Newfoundland.

European Fishing Fleets in American Waters. Fishing fleets from France, Portugal and Italy still visit the Grand Banks, and although Newfoundland belongs to Great Britain, the French fishermen may by treaty right fish along the shore of the greater part of Newfoundland. They may also land and dry their fish, although no permanent French settlements may be made. France also owns two islands, Miquelon and St. Pierre, situated just south of Newfoundland, with a population of a few thousand dependent entirely upon the fishing industry. This single product serves to give these islanders a per capita trade exceedingly heavy, many times as heavy as that of the United States.

North European Fisheries. The North Sea is the greatest fishing ground in the world. It is very shallow and abounds in fishing banks. It is surrounded by populous lands, being within easy reach of the British, French, Belgian, Dutch,

German, Danish, Swedish, and Norwegian fishermen, and belongs alike to all of them, since by the custom of nations, the sea three miles and more from shore is free to all mankind. These peoples having access to the North Sea catch about $250,000,000 worth of fish per year, and the greater part of them come from the North Sea.

Great Britain has become the undisputed leader of the North Sea fisheries. In addition to a wide variety of motor-driven and sailing craft, Britain employs more than 3,000 steam fishing vessels. The industry is centralized in a few large ports such as Aberdeen, Hull, Lowestoft, Yarmouth, London, and especially at Grimsby, which is the greatest fish market in the world. The thousands of tons of fish brought into Grimsby by the trawlers are handled at a special harbor built for the fish trade, and equipped with a covered pier two stories high and nearly a mile and a half long.

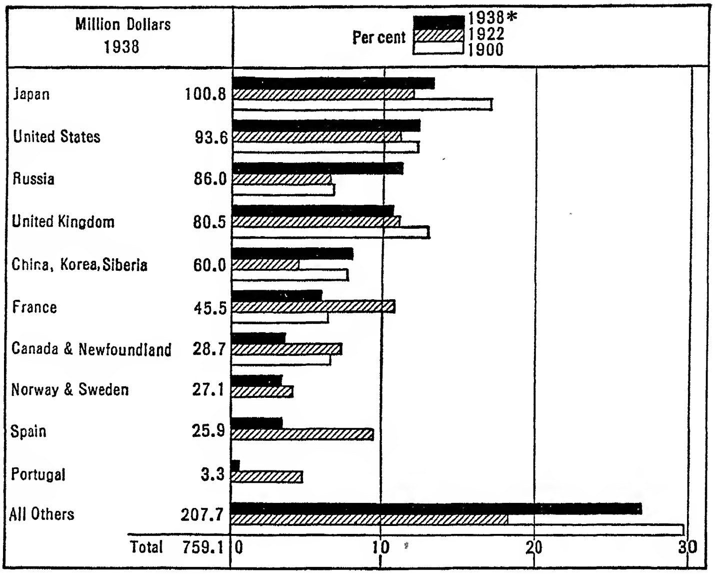
The Dutch, by their location more dependent upon the North Sea than are the British, fish nearly as much per capita as the British and have a fishing fleet with 17,000 men. The French, having no fishing banks along their coast, sail as far away as Newfoundland and Iceland.

Norwegian Coast Fisheries. Norway is of all the nations except Iceland the most dependent upon fish. That the hardy Norse have been able to people their bleak and rocky coast all the way up to the Arctic has been due largely to this harvest of the ocean. In past ages the glaciers on their way to the sea cut deep furrows in the mountain mass of Norway, so that her present coast line resembles a huge jagged saw. These protected fjords, some of them over 100 miles long, form excellent harbors and fine fishing grounds. There is a small town or a tiny village in nearly every one of them. Fishing in this northland is not managed by large companies with expensive boats and equipment, but is largely in territorial waters and in the hands of the small independent fishermen. It is also a part-time industry. At the season when the cod and herring swarm into Norwegian waters to spawn, the small farmers and village tradesmen get out their boats and become fishermen for a spell.[1] In 1937 they caught 900,000 tons of fish (herring 520,000, cod 210,000) and exported about a third of them.

Norwegian salted herring, codfish, and cod liver oil have become standard products in many distant lands.

Fisheries of Japan. The third fishing region of importance is on the coasts of northeastern Asia, where again we have a cool climate and rough shores, such as prevail in the same latitudes in eastern North America, and northern Europe. While the United States catches four billion pounds, Japan leads the world with eight billion. The Japanese are credited with eating more fish than any other people in the world, 55 pounds per capita, as against 13 pounds in the United States. Two reasons account for this. One is the almost entire absence of the meat animals in Japan, and the other is the abundance of fish in the waters surrounding the country, which

[1] Of 109,000 fishermen in Norway, 27,000 have no other means of livelihood, 44,000 are mainly fishermen, and 38,000 have other more important sources of income. The majority of the two latter classes are also small farmers.—*London Times Trade Supplement,* April 14, 1923.



* 1933—Spain, U.S.S.R., Newfoundland; 1936—Japan, China; 1937—United Kingdom, France, Norway.

International fishing by per cent at three periods, by millions of dollars at the last period. This map shows a rather surprising number of declines, the chief gainer being Russia, and presumably Siberia.

happens to be composed entirely of islands, thus tempting its people to go to sea. Hokkaido, the northernmost of the four large islands of Japan, has a little coal mining and a little lumbering, and some agriculture of the northern Wisconsin type, but is too cold for rice growing. Much of it is too rough for any other kind of agriculture. Its people, like those of Norway and Newfoundland, must depend largely upon the catch of cod, herring, and other fish of north temperate latitudes.

Japanese fishermen scour the coasts of Asia, especially those of Korea, the Kurile Islands to the north, and the cold island of Sakhalin. Fishing is one of the principal industries of Sakhalin, the main varieties taken being salmon, herring and plaice. Treaties with Russia have given the Japanese fishing rights along the entire Siberian coast,[2] with nearly 12,000 miles of shore line. This is of great importance, as it helps to supply not only the chief animal food of 75 million people, but also an important fertilizer, made of dried fish refuse and non-edible fish, and extensively used in the well-tilled gardenlike farms of Japan. Since 1930 Japanese fishing vessels and factory ships have operated in the vicinity of Bristol Bay, Alaska.

[2] Under the Fishing Convention of 1916, amended each year, Japan was given liberal fishing rights in Siberian waters from the Korean border to Bering Strait. By the terms of this convention fishing concessions, including a small tract of land on the adjacent shore where fish may be cured, canned or salted, are auctioned off every year. The bidding is limited to Russians and Japanese, the seacoast stations going almost entirely to the Japanese fishermen, while the bay stations are in the hands of the Russians. The future of these rights is still uncertain.

Operations apparently have been confined in the main to the capture of crabs, which are canned aboard the factory ships. In some years the pack has amounted in the aggregate to more than 50,000 cases. From time to time Japanese steam trawlers also operated in this area, catching so-called "trash" fish, which were reduced to meal and oil aboard accompanying factory ships anchored offshore. The output of these fish-reduction ships is not known. In the summers of 1936 and 1937 Japanese fishing vessels, using long, floating nets, were engaged in the capture of salmon off the coast of Alaska in the vicinity of Bristol Bay. It is understood that these fish were canned aboard Japanese floating canneries anchored nearby. There was much alarm in the United States. It was feared that the Japanese had solved a mystery—found the salmon before they got to shore waters.

The Fisheries of the Open Sea. Mackerel, unlike the cod, are surface swimmers, and are caught in nets swinging in the open sea. They are caught off the coasts of Europe and the United States, and sometimes they are immediately preserved in salt brine.

The sardine, deriving its name from Sardinia, is a small pilchard, dried, packed in oil, and sold in sealed cans. It is exported largely from France, the sardines of the Mediterranean being packed for shipment at Beauclaire on the Rhone, while Bordeaux upon the Bay of Biscay is a great center. Sardines are also caught along the coasts of Spain, Portugal, and Italy, but a kind of sprat is often sold under the name of sardine, and many other kinds of small fish masquerade as sardines. Along the eastern coast of the United States there has long been an important industry in the so-called "American sardines" which are really small sea herring, a fish closely allied to the pilchard. Although the Maine sardine canners have to dry their herring with artificial heat while the Frenchmen can do it in the sun, the American product is much cheaper and is shipped all over the world. Of late years the canners of both Europe and America have discovered that the cheaper vegetable oil can be used in the place of olive oil in fish canning.

The Menhaden Industry. The early American colonists were taught by the Indians to place a fish in each hill of corn for fertilizer. The menhaden, a fish long considered unedible because too oily, swarms the waters of the Atlantic coast from Florida to Newfoundland, is now caught by millions every year for the same purpose. Small fishing steamers carry on the fishing in the open sea, using nets many hundred feet long. When a school of menhaden, swimming near the surface, is sighted by the look-out on ship or airplane, the net is drawn around the fish, pursed at the bottom, and the fish ladled into the hold. The shiploads of menhaden are taken to fish factories, along the coasts, where they are cooked by steam and pressed, emerging as fish meal for feeding live stock, oil for soap making, and fertilizer (rich in nitrogen and phosphoric acid) for the farmer's corn. A new process removes the undesirable oil, and menhaden now come to the table as canned fish.

Whaling. Of all fishing enterprises whaling is the least dependent on home ports of ships and particular shores. It is also essentially an industry of the past. It was of very great importance in the

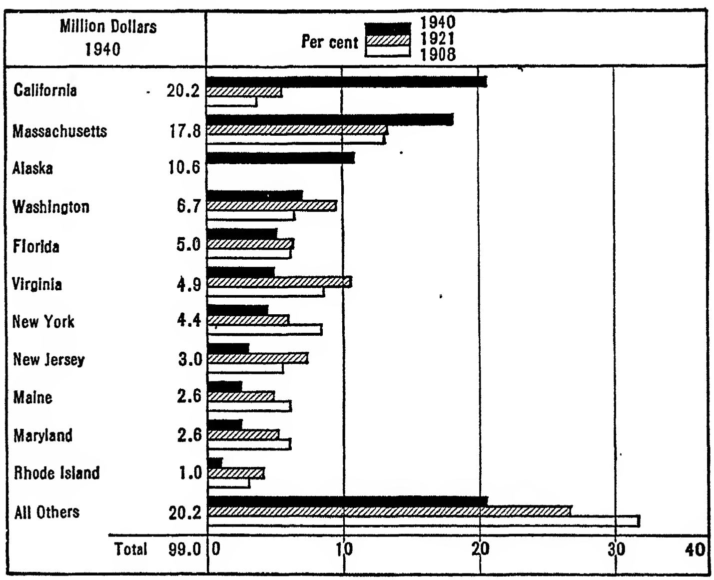
first half of the nineteenth century, when whale oil supplied the family lamp. In those days New Bedford and Nantucket in Massachusetts and New London, Conn., were the great outfitting centers of an industry that was prosecuted in all oceans of the world so persistently that the whale was nearly exterminated by 1860, when the discovery of petroleum lessened the demand for whale oil, corset steel replaced whale bone and gave the monsters of the deep a little reprieve.

The Norwegians, still catching whales in the Antarctic, sold a million barrels of whale oil in 1937. Whale oil is now an edible oil.

Tuna and Shark Fishing in California. California has risen rapidly to first place in fishing statistics due to the increase of tuna fishing and the sudden prominence of the shark. This villain of the deep now goes to market a victim of the vitamin style. His liver is very rich in vitamins—worth $10 million to our fishermen in 1943. Since the shark eats big fish the shark fishery may have double value. We may get him and his food.

Sealing. The seal gets its living (fish) in the sea, rears its young upon the rocky shores, and is the prey of man on both sea and land. It is such a valuable and easy quarry that extinction seems to be its fate where not protected by strictly enforced legislation.

The great center of fur seal fishing is the Pribilof Islands, an American possession in the Bering Sea. Here each year many thousands of seals gather from distant seas, and remain for a few weeks during which time the seal pups are born and grow large enough to swim away with their mothers. Unfor-



U. S. fishery products during three different periods, with value of the last. The eastern states south of Massachusetts have declined sadly, due largely to exhaustion of oysters, shad and alewife (called herring). The frozen filet has put Massachusetts ahead, but not so much as California, which has become the new giant among fishing states.

tunately for the seals no country has in past years had any jurisdiction more than three miles from its coasts, and the seal at sea was like the whale, beyond the protection of government. While the United States could and did protect the seals during their stay on the rocks of the Pribilof Islands, the mother seals daily swim to the open sea for fish, and during many months the whole herd is scattered widely over the Pacific Ocean. When more than three miles from shore they fell a prey to the rifles of the pelagic sealers from Canada, Japan, or the United States, who sailed the seas in search of them. As a result the mothers of many little seals were shot while gathering food, leaving the young to starve on the rocks. Thus the number of seals in the Pribilof herds rapidly declined and extinction seemed only a matter of years.

Such an economic insanity was averted by a sealing treaty (1911) drawn up between the United States, Japan, and Canada. This treaty protected the seals because the three nations agreed to stop pelagic sealing, and the United States agreed to divide the proceeds of the monopoly which she held because she owned the seal rookeries. As the seals are polygamous, a certain proportion of the young males can be captured each year without in any way lessening the rate of increase of the herd. The seals were killed under government supervision, the number of pelts taken in 1923 being 16,000 and 117,000 in 1943. The skins are sold at the great St. Louis fur auctions. Under the careful management of the government the Pribilof seal herd increased from 215,000 in 1912 to 653,000 in 1923, to 2,338,000 in 1941.

The Pribilof Islands are the only place where the Alaska fur seals ever seek the shore. The Alaska fur seal herd represents about 80% of the fur seals of the world. The treaty of 1911 was abrogated by Japan on Oct. 23, 1941, the Japanese claiming that the seals inflicted both direct and indirect damage on their fishing industry. The United States used to get 70% and Canada and Japan 15% each. Now the United States and Canada have signed a provisional agreement under which this country will get 80% and Canada 20%.

A less valuable seal (hair seal), sought for its oil and leather, is common in Labrador and Arctic America, and a fleet of steam sealers sails from St. Johns, N. F., on an annual sealing voyage. Single vessels have been known to bring back 30,000 skins.

Shore and River Fisheries. A number of marine animals such as the oyster, clam, lobster, and sponge live in shallow waters where they can easily be caught. Many rivers and bays have a fishing value out of proportion to their area, because of the sea fish that annually enter the stream for spawning and become the rich harvest of the fishermen.

The sturgeon, the largest of these visitors, is a fish that grows as much as 10 feet long and is found to some extent in the American Great Lakes[3] and the rivers of the Atlantic, but in greatest quantity in the Caspian Sea, whence years ago it ran up the Volga River in such quantities that at times they crowded each other out of the water in narrow places. The fish are caught in

[3] This marine fish, like the seals of the Caspian Sea, seems to have survived from the time when the Lakes were connected with the ocean.

part for their eggs, which are sold as Russian caviar, and the industry has been prosecuted so vigorously that this valuable fish is about to become extinct. The industry has practically disappeared from the Atlantic rivers of America and has greatly diminished throughout the world, but the rising price of caviar makes sturgeon containing eggs more and more valuable, and the quest more fierce—another example of our idiotic practice of letting a man for his own small gain wreck the resources of mankind.

The salmon, of which there are several species, is easily the king of all river-running fish. Living most of their life in the ocean, the salmon return again to the fresh-water streams where they were originally hatched in order that the females may deposit their eggs. Salmon are found to some extent in northwestern Europe, New England, and Canada, but the rivers of the North Pacific, between San Francisco and Japan, are the chief source of the world's supply. In 1937, 330 million pounds were caught in the rivers and off the coast of eastern Siberia, a third from the Amur River. In Alaska they have for an unknown period been almost the only food supply of the natives, who at the time of the annual run put away the year's supply of smoked salmon in little houses on high poles, out of the reach of wolves and dogs.

The Pacific coast salmon industry is our most important commercial fishery, with a catch of over 560 million pounds in 1940. Salmon canning was first established in California, Oregon, and Washington, then in British Columbia and finally in Alaska, where in almost every river, especially the great Yukon, salmon are exceedingly abundant. They run in great numbers and are caught with gill nets, purse seines, fish traps. Large salmon canneries have been built at the mouths of various streams in Alaska along coasts so rocky and cold as to be undesirable for human habitation throughout most of the year. As the season for the salmon running approaches, vessels loaded with empty cans and carrying many workmen leave San Francisco, Portland, or Seattle for the cannery. In a few weeks hundreds of thousands of pounds of salmon are canned, loaded into the vessels, and brought back to the home port. The annual pack, valued at $62 million in 1942, is distributed throughout the United States and exported to all parts of the world.

Seattle is the most important fishing center on the Pacific coast largely because of the salmon fisheries, and, in the United States, is exceeded only by Boston, Portland, Maine, and Gloucester.

The shad, probably the most highly prized of American food fish, ascends each spring the rivers from Florida to the St. Lawrence. North of New York this fish is unimportant and the estuaries of the Chesapeake furnish about one-fourth of the total catch. The river herring also ascends these same streams in such numbers that at times their scaly backs make the surface of the water to shine almost like a mirror.

Shellfish. The oyster in the United States is exceeded in value only by salmon and tuna. This delicious shellfish, which furnishes about one-eleventh of the total value of all fisheries of the United States, lives on the sandy and gravelly bottom of shallow bays and estuaries. It is found to some extent in

the English Channel and the Bay of Biscay and on the Pacific coast of the United States, but the numerous bays between Cape Cod and Galveston, with their large expanses of shallow water of suitable temperature seem to be the best place in the world for oysters. The oysters of best repute are produced between Cape Cod and Cape Hatteras, and the Chesapeake Bay, an old river valley into which the sea has flowed, is the most important oystering district of all, producing half of the American crop. The oyster, after being hatched from the egg, swims around for a time and then attaches itself to some firm substance, such as gravel, an old oyster shell or sunken wood. For two or three years he eats whatever the tide brings him, and is then scooped up with long-handled tongs in the hands of an oysterman or by a steam-drawn dredge. During the seven or eight months of the oyster season they are shipped in barrels and sacks and iced containers all over the United States and even to Europe, while at Baltimore there is a canning industry now second to Biloxi, Miss.—the world capital of canned oysters. The shells are ground and used as grit for poultry, or as lime for the soil to counteract acidity. The natural supply having been found inadequate, oyster culture has been established. Beds of young oysters are sometimes planted, that is, put down to grow large; another method is to lay old oyster shells and the bushy tops of trees upon the bottoms of the bay so that there may be something to which the floating spawn may attach themselves and grow. Although the oyster fisheries have decreased by half in the past fifty years, the possibilities of extension by artificial culture in Long Island Sound, and in Delaware, Chesapeake and other bays are very great.

Clams and Lobsters. Clams alone yield greater cash return to the American fisherman than the codfish. The clam is a cousin of the oyster but possesses power of locomotion and is caught by being dug out of the mud. It is especially important along the New England and Middle Atlantic coast.[4]

The clam fisheries yield approximately 30 million pounds of meat annually. If proper methods of clam cultivation were practiced, it is estimated that the annual production could be doubled. The much-prized lobster, a great crayfish and cousin to the crab, lives along the seashore and, from the mouth of the St. Lawrence River to Cape Hatteras, is caught in a baited box trap called a lobster pot. The high esteem of the lobster causes it to bring about six times as much per pound as the codfish. The consequent keen prosecution of the lobster fishing has caused the passage of severe laws (rarely enforced) to prevent its extermination along the shores of the United States.

Lobsters were once so plentiful that

[4] "The bottoms of millions of acres of shallow waters are studded with albuminous jewels called clams. There are parts of the northern coast from Maine to Labrador where these are so abundant that they actually constitute a considerable proportion of the floor of the bays, and yet they are for the most part unused. A thousand years from now many of the neglected mollusks and still lower forms of animal life in the sea will be served in the form of delicious tempting repast upon our tables. . . . The relative value between sea foods, which cost man little or nothing to raise, and land meat which costs man a great deal to raise, show no considerable differences excepting in the large fat content of land meat." —*A Surgeon's Philosophy*, by Robert T. Morris. M.D., pages 239 and 240.

The clam is the chief food of the walrus.

they could be bought for a penny apiece. The present catches are small, but because of the high price, New England fishermen receive a larger income from lobsters than from any other shell fish. The largest producer of the world is Canada. The import from Canada in 1940 was 11,929,091 pounds of fresh and 1,231,177 pounds of canned lobster.

The Sponge. The sponge of commerce is the fibrous skeleton of a marine animal whose jelly-like body is washed out before the sponge is dried for shipment. The sponge grows at the bottom of warm shallow waters, the finest sponges coming from the Mediterranean coast of North Africa, between Morocco and Tunis, and the Adriatic Sea. They are commonly found here to a depth of 150 to 200 feet and are brought up by divers. In the still, shallow water around the coral Bahama Islands there were many sponges that made Nassau an important sponge fishing center. It is all over now. A mysterious disease killed all the sponges. What can man do about that?

Tarpon Springs, Florida, the center of the American sponge industry, is the headquarters for the Greek divers [5] who bring from their beds on the rocky bottom of the Gulf of Mexico the sponges that are regularly auctioned in bunches at the local sponge exchange. The growing scarcity and high price of free sponges has led to experimentation with sponge-farming, seed sponges being fastened to weights and put upon the sea bottom to grow.

Pearl Fishing. Pearl fishing is a shore fishery not possessed by the United States, since the pearl is found in the shell of certain inedible oysters that inhabit tropic waters. The pearl is a product of accident, being deposited around some foreign substance that gets inside the oyster shell. The output of pearls is, therefore, uncertain, and often the fisheries are non-productive. The finest pearls and most important fisheries are upon the southern shore of Persia in the Persian Gulf, where for ages this industry has been important. The shores of Ceylon also have a pearl fishery. America has one small ~~center in some~~ small islands along the coast of Venezuela. In addition to pearls, the pearl-like covering of the inside of the shells of these oysters is sold as mother-of-pearl. A similar pearly shell used for button making is yielded, to the extent of 18,000 tons per year, by certain mussels inhabiting the upper Mississippi River and some of its tributaries.

The Importance of Fish to the Atlantic Plain of the United States. In the central part of the Atlantic Plain of the United States, unusual fish resources combine with many other resources to make the peninsula between the Chesapeake Bay and the Atlantic Ocean one of the most favored places in the United States or the world for the easy support of the human race under physical conditions that place no serious handicap on man. The climate is wholesome, the varied soil, abundant, well-distributed rainfall, and satisfactory temperature permit the commercial production of an unusual variety of grains, fruits, and vegetables, while wild game and fish products reach their maximum of abundance. It is the greatest oyster and river herring locality, and many minor fish

[5] The head of the Greek church in America blesses the industry in the elaborate ceremony of its annual opening. Greeks discovered important sponge beds in the Gulf of Mexico.

are caught. Herring are so abundant that the laboring man may in the springtime buy a thousand for a few dollars, and with a sack of salt and a barrel they can be preserved for the entire year. As herring and corn bread make a sustaining meal (materials costing three cents) for a working man, living is exceedingly cheap.

The advantages of this peninsula are in the main typical of the whole Atlantic coastal plain that extends from the Fall Line to the ocean and includes Long Island and Florida.

~~**Fish in Southern Waters.** It~~ is a fact that southern waters contain more species of fish but fewer fish than the colder waters of the North. The heat causes fish to spoil quickly, rendering difficult the marketing of the product. Recent improvements in means of artificial refrigeration make it possible to catch fish in the waters of Florida or the West Indies, freeze them at once, and market them weeks later in New York and Europe, in the same way that fish are now marketed in the winter season in those markets from the waters off Vancouver Island and other distant places. We may, therefore, anticipate a development of the fishing industry in southern waters, although little has yet been done.

Seaweeds of several species are gathered in many places and are yielding materials in increasing number and varied uses—food, medicine, paint, cosmetics. This is a promising field.

Fish Culture. Many centuries ago the Chinese and Japanese found out that fish growing in ponds and rivers is one of the easiest ways of getting meat in a densely peopled country. Oyster culture was an art among the Japanese a century before the Declaration of American Independence. There are many fish ponds in Europe. The German people are systematic fish growers, devoting themselves chiefly to the carp, a fish that can be fed in a pond like poultry in a yard. There are many fish growers' associations in Germany and the total area of fish ponds approaches 200,000 acres. In Saxony one-half of 1% of the area is covered with fish ponds. (Compare with the 3% under cultivation in Cuba.) The fish are fed upon corn, vetches, potatoes, malt, snails, slaughter-house refuse, and many other foods. The average yield is about 100 pounds of fish per acre per year, and much higher yields are sometimes made. Farm fish ponds are being advocated in some parts of the United States and may be built in great numbers. We now know that commercial fertilizer, put into the water, causes microscopic vegetation to grow and produce 150 pounds of fish per acre per year—bass and blue bream recommended.

The threatened extermination of many valuable species of fish has led to systematic fish culture, which has thus far been chiefly devoted to collecting the eggs, hatching them and caring for the fry for a short time. The United States Government has a fish commission which hatches billions of fish eggs and releases the fry in streams and lakes to replenish the supply. There are several salmon hatcheries in Oregon and Washington, shad hatcheries in the eastern rivers, lobster hatcheries upon the New England coast, and hatcheries upon the Great Lakes for whitefish, lake trout, and other fresh water varieties. The governments of Canada, Norway, Switzerland, and Germany are

also aiding the industry by the same means.

The baby salmon, hatched in the icy waters of a glacial lake far up on the Columbia, the Yukon, or any other river, goes back to that same river when the wander years at sea are over. An important and agitating question was whether the huge new dams on the Columbia River would end the salmon business. After careful trials, the fishing experts say "no." In 1943, the salmon run proved that they could take fecund salmon from the Columbia at a dam, put them in tank trucks, haul them to a branch stream that reached the Columbia below the dam, and that the little salmon would go back to *that* stream. It made no difference where *mother* was born. The way that a salmon returns to place of birth is one of the many amazements of nature.

Fish are exported by cool countries, imported by warmer countries. The United States produces about 32 pounds per capita and consumes 13.3 pounds. The United Kingdom produces 55 pounds, and consumes 35 pounds. The great fish-importing countries are Italy, Spain, and Portugal, where the Catholic church lays certain restrictions upon the use of meat and the poverty of the masses of the people limits them to a food that is cheaper than meat. The Latin-American countries and Brazil are also important fish importers for the same reasons that exist in south Europe and the added one that in such hot climates fresh meat and fresh fish spoil very quickly while the dried cod, resembling a piece of wood in hardness, appearance and durability, keeps indefinitely even in hot climates. The dried cod or stock fish is, in combination with corn bread or corn-meal mush, a staple article of diet alike in Venice and Valparaiso, Lisbon and Yucatan.

Possible Future of Fisheries. Oceanography is an undeveloped science. The sea is an unknown resource. Perhaps its fisheries offer our greatest possibility of easy extension of the human food supply. When we consider that three-fourths of the earth's surface is sea and that it teems with microscopic plant life and animal life, nearly all of which has food value, we begin to see how great may be the possibilities of its full utilization.

Our ignorance of it is well illustrated by the fact that Europeans made revolutionary discoveries in the art of catching sardines in the year 1900 and again in 1915.

We see the limiting influence of prejudice in observing the way we have thrown away the flesh of thousands of whales per year when it is about as good and nutritious as beef.

The chief bulk of marine life is not in the whales or the fish we now eat but in the smaller forms, mollusks the size of a grain of corn or grain of wheat or a lead pencil point that move about the sea in masses containing innumerable millions. These small fry, the food of the present food fish and of whales, are in some cases nutritious for us also, and the art of food preparation and preservation can make them good to eat and keep them till wanted. The airplane is already coming into service to discover these and other schools of marine life which men may catch.

The echo-sounder, brought to high perfection during World War II, promises to be a great aid to fishermen in shallow seas. It will report the character

of the bottom almost as though men saw it.

Most suggestive of all, however, for prompt results, is the discovery, now well established, that fish meal in combination with the existing rations, reduces the cost of producing beef, pork, and poultry. While we may slowly, through the generations, learn to eat semi-microscopic mollusca, the sea may be quickly patrolled with airplanes, guiding the floating factories to the masses of mollusca to be scooped up and turned into cargoes of cow feed, pig feed, and poultry feed for the indirect nutrition of humans.

Leather and Rubber

1. The Raw Materials for Leather

Antiquity and Distribution of Leather. Leather making is one of the oldest industries. If man has been man for 500,000 years, as some anthropologists think, when did he not modify skins to make leather? Leather is made by cleaning and treating skins so that they will keep, and the skins are furnished by a great variety of animals. Naturally the domestic animals—the ox, cow, sheep goat, horse, and pig[1]—lead, but many other animals contribute their small quota to the world's leather. Among these are the alligator and crocodile, the manatee, or sea cow of tropical rivers, the shark, the monkey, the serpents, and the wolves. The skin of man himself is at times converted into excellent leather, and the white whale of the Arctic Sea yields a strong and watertight skin called porpoise hide. With this great variety of sources, practically every trading people sends some kind of skins to the world's market, and even among the more primitive men, skins are the chief riches.

Leather is as old as trade, and the industry contributes to the commerce of every nation and every people, sometimes in the form of hides and of raw materials for tanning, sometimes as finished leather, which is the raw material of shoe factories and other leather works, and, finally, in the form of shoes and other leather manufactures.

The Trade in Hides and Skins. The term hides is applied to the skins of cattle and horses; skins, to those from sheep, goats, and smaller animals. The United States leads all other countries in the manufacture of leather, and although the meat of animals is one of our greatest exports, the import of hides and skins, amounting to over 300 million pounds a year, is one of the greatest items of our import trade. Practically every country in the world contributes some of these raw materials, which cost us 50 million dollars in 1940. Of goatskins alone we import millions of pounds a year, and they come chiefly from India, Brazil and Mexico, lands having the arid conditions in which the goat thrives better than any other domestic animal. Most of our import of cattle hides comes from the plains of Argentina and Brazil, and the Canadian extension of the American plains and plateaus supplies the next largest share. We also draw hides and skins from every country in Central and South America, because dried or salted ox hides, proof against rain, dirt, and blows, baled in any size or form, carried by any means, are one of the safest and most convenient commodities that can be carried over rough and difficult pack trails. The raw hides export much more easily

[1] The difficulty of curing pork after it is skinned causes us to lose a large leather resource estimated at $3,000,000 per year in Britain alone.

than leather, and the lack of industrial development in those countries makes tanning difficult there. In addition to the importation of hides from the rough, the arid, the poor, and the undeveloped countries, which cannot tan, we also get them from the richest and greatest manufacturing nations in the world—England, Germany, France, and Russia—where the fuller utilization of resources, due to a dense population, has produced a scarcity of tanning materials. One of the many results of two world wars has been, first, shutting off of supplies and then the development of home industry. Thus a tanning industry has sprung up in Argentina, Brazil, India, Australia, and South Africa, and consequently our imports of hides and export of leather are likely to go down.

Tanning Processes and Materials. Tanning usually consists in treating the skin with a strong astringent, tannin, a very common vegetable substance which unites with certain elements in the hide and changes it from a material prone to decay, to one of great durability. Tannin, like sugar, is widely distributed among plants and is found in workable quantities in all continents. Its usefulness in tanning seems to have been discovered independently, long ago, in many parts of the world. Columbus found the American Indians with leather of excellent quality, and about the only people who do not know how to tan it are the central African tribes south of the Sudan.

Until late in the last century the peoples of Europe and America depended for tanning almost entirely upon the bark of oak in southern, and hemlock in northern, locations. The growing scarcity of forests and the increased supply of hides which world commerce produced, has created a lively trade in other tannin-producing materials, so that now no less than fifty of them are in use, but not more than ten are important. With the increase in distant commerce, there is a growing tendency to ship these materials in concentrated forms, thus lessening transportation costs. The concentrates were formerly made only in tanning factories where used, but now they are to a great extent made near the centers of production. Thus the oak bark which England imported from Holland, Belgium, Hungary, and Italy contained from 10% to 12% of tannin, while the concentrated form now shipped has about 30%. The oak wood itself, which has from 2% to 5% of tannin, contributes its share through extraction from sawdust and waste scraps yielded by the sawmills of Hungary and Italy. In central Europe tannin is also extracted from the bark of Norway spruce for shipment to the tanners of England and Germany.

England gets from India another tanning material known as myrobolans, the dried fruit of a leguminous tree growing abundantly in central India and furnishing the chief tanning material of that large country. It is shipped in large quantities to Europe.

Sumac is a shrub or small tree growing wild in Austria, the Balkan states of Europe, and in the Appalachian region of the United States. In Sicily it is cultivated for its leaves, which are regularly cut and dried like hay and shipped to the tanneries powdered and in sacks. The Sicilian sumac industry fits well into the industrial conditions of that overpopulated island. The plant grows without tillage on land

too dry and rough for other crops, and it affords employment when other work fails and other crops do not need attention. Appalachia once harvested and shipped sumac for tanning but now has more lucrative employment for her workers. The Sicilian industry also is declining.

Valonia, a rich tanning material, is nothing more than the acorn cups of the valonia oak (also called Turkish oak) picked up by women and children in the forests of the Balkan Mountains, Asia Minor, and Greece and shipped to England where it has largely replaced the use of oak bark now so scarce in that country.

Australia exports the bark of the wattle tree, a member of the acacia family, with bark yielding as much as 40% tannin, making it the richest of all tanning materials. In Natal this tree is planted for its rich harvest of bark which it yields in from five to twelve years.

Quebracho is today the world's greatest source of tannin for tanning heavy leather. The quebracho tree (the name means ax-breaker), a natural monopoly of South America, is found throughout a large part of the Gran Chaco—an extensive unsettled tropical forest in Argentina and Paraguay. There is also some quebracho in Bolivia and Brazil. This medium-sized tree has a very hard wood containing 20% or more of tannin which renders the wood almost indestructible in the ground, thus making it valuable for railroad ties. Its richness in tannin has caused a rapid increase in the shipment of quebracho to the tanneries of England, Germany, and the United States. Argentina exported nearly a quarter of a million tons in 1936.

Since the wood is heavier than water and is very difficult to get and transport, the extracting plants are, like sawmills, in rough country, located as near as possible to the place where the trees are cut. The industry originally consisted of the exportation of logs for the manufacture of extract abroad. Since 1914 there has been a significant increase in the exportation of extract—now about three-fourths of the total on account of the great saving in transportation costs. When used alone quebracho extract makes inferior leather, but in combination with other materials it has become one of the world's most valuable tanning materials.[2]

In the Mediterranean countries, where the chestnut is common, this wood is furnishing an extract, and the same industry has been established in the Appalachian districts of the United States. While this wood is much poorer in tannin that quebracho, it is light and soft, grows in open forests, and is vastly easier to get to the mill than the heavy tropical wood. The chestnut tree increases in tannin content with age, and in America, at least, with lower latitudes, 6% in New York and 14% in Georgia. After the chestnut has been cut to bits and the tannin digested out of it, the pulp that remains is used for the manufacture of low-grade paper.

Mangrove, an otherwise worthless tree, grown on many tropic shores, is an important source of tannin.

[2] Despite the concentrated efforts of technical experts during a score of years to discover new and more valuable tanning materials, quebracho still holds its premier position because of its high tannin content and the unrivaled excellence of its extract as a tanning agent for sole and strap leather. (Commerce Reports, April 9, 1923.)

The imports of tanning materials into Great Britain show well the widely scattered origins of tannin, and so does the American import.

TABLE 38

BRITISH IMPORTS OF TANNING MATERIALS

(In hundredweight)

	1920	*1937*
1. Barks		
Oak (America).....	2,586	
Chestnut (France, Italy)...........	108	
Quebracho (South America).........	285	
Other sorts (Bengal, Australia, etc.)...	695,951	292,700
2. Sumac (mostly from Sicily and Algeria)	124,958	54,200
3. Gambier (Malay Peninsula, Sumatra)..	64,862	28,000
4. Myrobalans (from India)............	718,329	667,200
5. Valonia (Greece, Turkey)...........	174,228	71,900
6. Other sorts (Chile, Venezuela, etc.)...	22,075	
7. Extracts		
Oak (America).....	5,060	22,400*
Chestnut (France, Italy)...........	303,346	355,700 †
Quebracho (South America).........	447,710	400,500
Other kinds (South Africa, etc.)......	146,830	567,700
8. Nut galls (China, etc.)	39,270	

* From Yugoslavia.
† Chiefly from France and U.S.A.

The United States, with its large domestic sources of vegetable tanning materials, relies on chestnut, bark or extract, for about one-third of its supplies. One-half of our vegetable tannin comes from quebracho wood or extract imported from Argentina, and lesser amounts of other materials come to us from all over the world.

A chemical process using chromium suffices for light leathers such as are used for the uppers of shoes. This was a great relief to our forests. Since 1900, 75% of our light leathers have been chrome-tanned.

The Making of Leather. The United States makes $350,000,000 worth of leather per year. The industry, which gives employment to 50,000 people, is one that has had greater changes in material than method. The common method is to put layers of bark between the hides and then soak in water for two to four months, while the tannin does the work. The chrome process requires but a few hours.

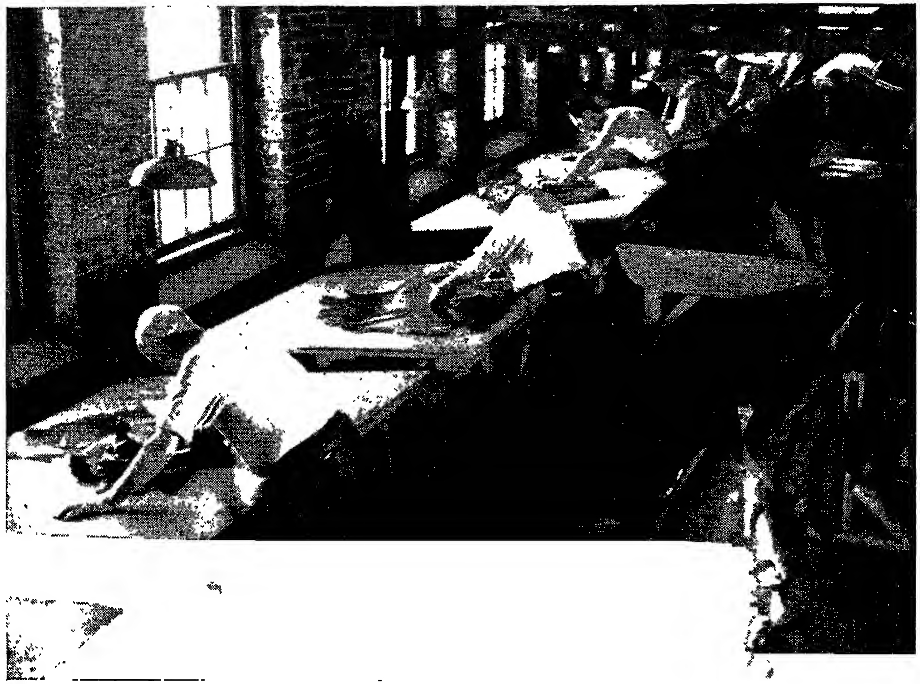
TABLE 39

U. S. IMPORTS OF TANNING MATERIAL, 1937

(In 1,000 pounds)

Quebracho wood..............	31,385
Myrobalans...................	44,390
Sumac........................	361
Valonia......................	6,410
Gambier......................	3,178
Wattle bark..................	29,491
Mangrove bark................	8,080
Hemlock bark.................	1,107
Divi-didi....................	198
Quebracho extract............	112,025
Valonia extract..............	934
Myrobalans extract...........	730,000
Wattle extract...............	3,339,000
Mangrove extract.............	17,900,000
Other........................	557,000
Total....................	22,763,559

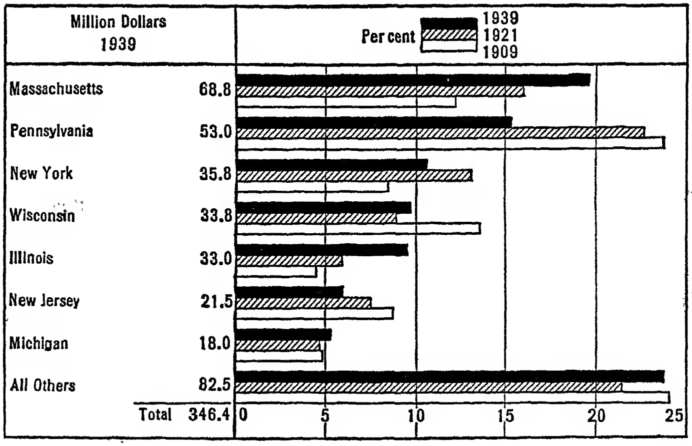
The supply of oak bark, which was the chief dependence of Europe until 1850, lasted longer in the United States, because of our great forest resources, so that the forest with its bulky bark located the American tanning industry down to the end of the nineteenth century. The valuable hides and leather



"Hand boarding" leather to bring out the fine grain. The pebbly leather, such as that used in women's handbags, is finished in this manner.

were easily portable. Tanneries were small affairs like the little country grist mill, and were scattered in rural hamlets and mountain valleys throughout Appalachia and New England. Hundreds of thousands of acres of oak and hemlock forests were bought by tanners, who cut down millions of good trees simply to strip them of their bark and let the logs rot because bark could be carried from rough nooks whence it was unprofitable to move the logs, and bark could be used in localities where there was no market for such a bulky commodity as lumber. The tanners often kept a team busy hauling hides and leather to and from some port, as Philadelphia, Baltimore, Richmond, and Alexandria.

Since 1870, the little tannery has followed the country grist mill. Many an Appalachian county that once had five or ten tanneries now has none. Between 1870 and 1940, the number in the United States declined 94%, but the capital invested in tanning increased fivefold. The workers increased 34%, and the value of the product doubled. Bark tanneries are still dependent upon the location of forests, but railways and trucks have made it economical to carry bark to a large tannery rather than to have many small tanneries away from the railroad. We have, therefore, two bark-tanning belts, one reaching the whole length of the Appalachian Mountains from New York to Carolina and the other in the hemlock region running from Massachusetts to Wisconsin, both of which are important leather states.



Leather tanned, cured and finished in the United States—three periods by percentages and value at the last period.

Chemical Tanning and Its Effects. Fortunately for the forest resources of the United States and the world, the chrome tanning process is practically independent of the forest or the field, and gives a different basis of location for the industry. The chrome leather industry, depending on factory products, labor, and markets, tends to locate in manufacturing centers rather than forest districts; and since it depends almost entirely upon imported goatskins for its raw material, there is some advantage in being near the ports of entry which are often near to shoe-manufacturing districts. This chrome process was first developed in Philadelphia, where it grew with great rapidity and helped to make that city the greatest leather-manufacturing center in the world. Philadelphia's specialties are patent and enamel leathers and vici kid. We import small quantities of special leathers from Europe.

Leather Making in Europe. Prewar Germany was the greatest leather-manufacturing country in Europe, with a specialty of colored leathers (dye industry). The industry was important in France, but the United Kingdom exported more leather in 1937 than both France and Germany. This is the kind of industry that postwar Germany can push. England buys nearly all of her hides from India, which country (with more cattle than any other) has, for 25 years, been exporting leather as well as hides to the mother country. In France, as in Holland, Belgium, and parts of Germany, we see in the leather industry an interesting adjustment to the density of population. The scarcity of forests long ago caused the establishment of willow plantations so trimmed as to grow long slender twigs for weaving the baskets that replace the boxes and barrels used in this country for the shipment of agricultural and manufactured products. These same basket willows yield a bark suitable for tanning a leather especially adapted for glove making. The dense population of France, Germany, and Belgium gives the labor supply to turn these good leathers into a

Lynn, Haverhill, and Boston. Manchester, N. H., and Auburn, Me., are really a part of the same shoe district, which sends shoes to every state in the Union and to many foreign countries. By 1939, New York and Massachusetts each made a fifth of the United States product, of which 85% was made in nine states—Massachusetts, New York, Missouri (St. Louis), New Hampshire, Illinois (Chicago), Pennsylvania, Maine, Ohio, and Wisconsin. The upper parts of the shoes are often made of imported goatskins tanned in Philadelphia. The shoe industry of the United States employs over 200,000 people, and the product in 1939 was worth $734,000,000, of which two-thirds was the cost of the expensive raw materials. As with the ready-made clothing, so with ready-made shoes, a wide market and large scale make possible the production of a great variety of shapes and sizes so that a greater and greater proportion of the people can be fitted with the factory product. This factor in combination with the smaller cost of machine-made goods in comparison to hand output, helps to explain the great and quick concentration of the industry. In 1937, we used over 3 pairs per capita; Canada, 2.2; United Kingdom, 2; Germany and France, 1.5.

The Foreign Trade in Shoes. The foreign trade in shoes seems destined to be small. The superior fit and comfort of American shoes are appreciated, and 40 years ago a large trade seemed to be in prospect, but the export of American shoe machinery has been followed by the ability of Europeans and others to compete in quantity production and American shapes. Indeed, the master shoe factory of the world in 1939 was in Czechoslovakia, and the Czechs had become our teachers. Our shoe export was 10.3 million pairs in 1913; 8.9 million, 1921; 1.5 million, 1940, out of a production of 424 million pairs—significant figures. This, in combination with preferential tariffs, has cut down the American shoe export. In connection with shoe export, the tropic habit of going barefoot should not be overlooked.[3] Shoes are almost unthought of by races that buy cottons by the million yards. Many nations that buy nearly all their cotton and woolen goods make nearly all of their shoes. The Indian who wears store clothes often prefers to make his own moccasins or have his wife do it.

Tendency of Shoe Industry to Spread. High freight rates and the heavy expense of shipping a bulky though valuable commodity like shoes help to explain the rise of new centers nearer the western markets than the Brockton-Lynn-Boston district. Labor difficulties in highly concentrated Massachusetts centers have caused shoe manufactures to locate in neighboring states during the last 20 years. New York City is now the second center for shoe production. St. Louis, where the shoe industry was established by the aid of Massachusetts foremen taken thither at extra high wages, has since 1900 advanced to the third shoe center in the United States. Rochester, Cincinnati, and Columbus, Ohio, have growing industries.

Glove Manufacturing in the United States. While many fine gloves come from France, Germany, and England,

[3] Cuba, drunk with sugar money, bought six million pairs from us in 1920. Sugar prices collapsed. Cuba bought 1.4 million pairs in 1921.

there is a production, chiefly for home use, worth $27,000,000 in this country in 1939. The glove industry is remarkably concentrated, the two towns of Gloversville and Johnstown, in Fulton County, N. Y., neither of which has 25,000 people, making over half of the gloves in the United States. There appears to be no reason for this other than that more than a century ago some Scottish people, members of the Scottish glovemakers' guild, settled here, and the house and village industry has been handed down from generation to generation until the sewing machine and the factory made it possible for these cities that had the start to maintain the leadership in this branch of manufacture, for which they have no natural advantage over a thousand other towns.

Harness and Saddles. The English people have for centuries been the greatest lovers and breeders of horses in the world, and it is quite natural that harness and saddles should be exported from this more than from any other country. In general it may be said that harness making is an industry that tends to be located in cities and small towns everywhere in the United States and Europe, no great centers having yet arisen.

The Future Supply of Leather. There is no sign of any diminution in the demand for leather. As standards of living rise, the people of Holland, Belgium, and Germany tend to lay aside wooden shoes, as do the Chinese and Japanese their leatherless footgear of straw, cotton and wood. But leather is destined to rise in price because it depends on animals, and animals are now becoming relatively scarce and must continue so if people keep on increasing or standards of consumption continue to rise. For example, the world does not possess the leather to make Western shoes for the Chinese. Leather substitutes should be welcomed and are increasing, especially in baggage, automobile and similar uses. In shoes they are generally regarded as inferior.

3. Furs

Furs are a branch of the leather trade that had a tendency to go down rather than up as the population of the world increased. This was because nearly all the furs were, until recently, taken from wild animals, many of which are carnivorous. As a further limiting factor, many of them live in forests and the forests are being cut and burned. Thus the woods of our two northern forest belts are the chief home supply of furs, but the chief part of some of the rarer product comes from the great sub-arctic forest that practically girdles the world from southern Alaska to Labrador and from Norway to Kamchatka. Throughout this vast and frosty region the wandering trapper annually makes deep journeys into the wild forest and emerges at the end of weeks or months with a bale of fox, muskrat, mink, martin, beaver, otter, sable, and other skins.

New York and St. Louis are the chief fur markets of America, receiving thousands of bales of furs from all over the world, which are sold annually at fur auctions. In like manner, Leipzig has been for many years the most important fur center of Europe, but its trade and position suffered greatly from World War I, and London surpassed it in the 1930's. In 1915, the price of furs went to almost nothing, because of the

Muskrat houses at Cambridge, Maryland, in one of the many wild life refuges that now, fortunately, dot the map of the United States.

When we start our fur farm, it is going to be muskrats. They build their own houses, get their own food, feed their own children, have several families a year, as rabbits do, and will eat good sheep feed if you provide it for them. Long live the muskrat! He is also excellent meat and offers a real industrial opportunity which is being used effectively on some swamp areas.

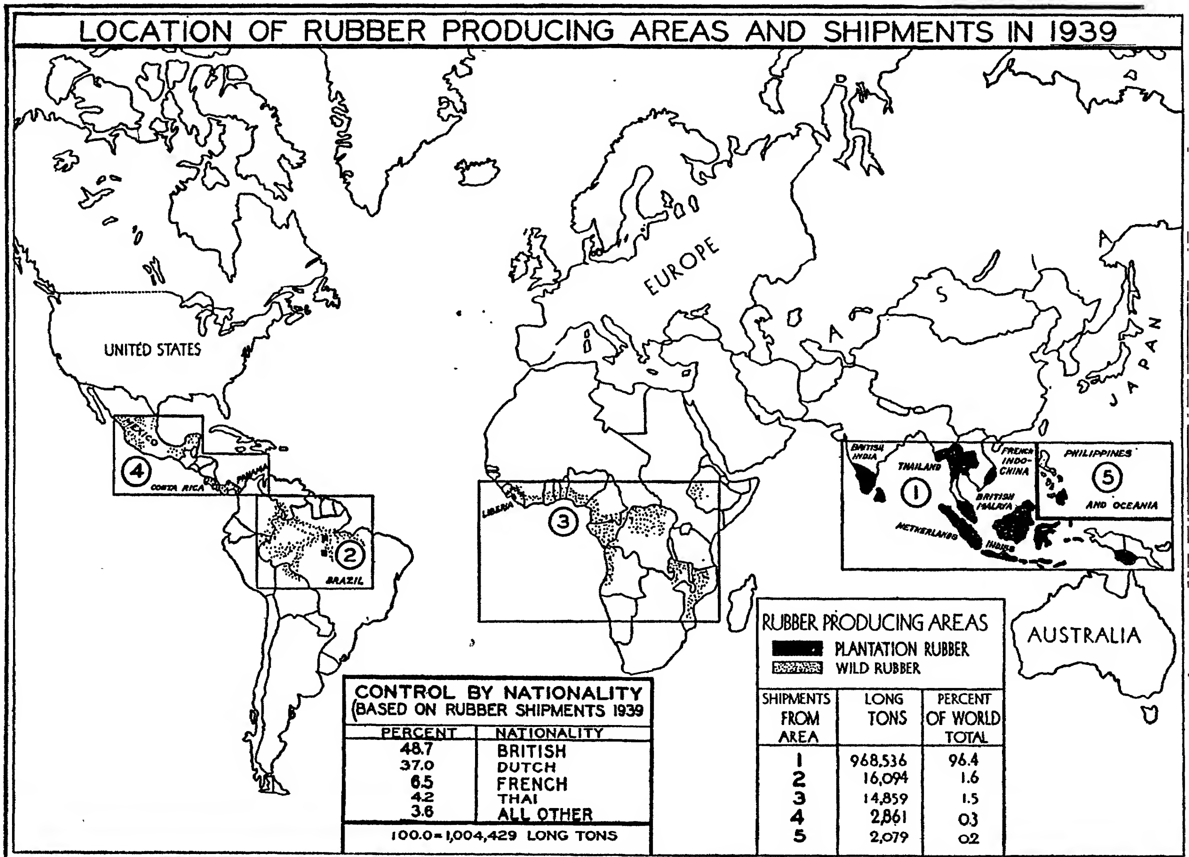
war, and the manufacturing of steel traps at Oneida, N. Y., suddenly stopped. In 1919 fur prices soared to unheard-of levels during the postwar speculative boom. In 1921 they slumped with dull times, rose with the boom of the later 1920's, slumped in 1930, and then had a bad dozen years.

In recent decades fur farming has become established in Canada and the United States in response to a keen and normally increasing, but fluctuating, demand. Starting in Prince Edward Island this suggestive new industry has become established throughout Canada. The enormous prices paid for the furs of the black fox have caused millions of dollars to be invested in fox farming, and several thousand dollars have often been paid for a single fine breeding fox. *All* the silver fox pelts come from fox farms and half of the mink.

In time we may expect to see furs from wild animals superseded almost entirely by furs from animals raised in captivity, just as wild rubber and wild quinine have given way to the cultivated crop. Already, fur farming has a busy output of literature and advertising, and the high prices are stimulating a fury of experimentation with fox, skunk, muskrat, opossum, mink and others.

4. *Rubber*

Columbus took back to Europe the report of a strange substance derived from the sap of a tree and which the natives used for balls and ornaments. Later explorers found it in use among the native Americans as a crude waterproofing for clothing. It was not until the last half of the eighteenth century that an English chemist found that it would erase pencil marks; hence the



CONTROL BY NATIONALITY (BASED ON RUBBER SHIPMENTS 1939

PERCENT	NATIONALITY
48.7	BRITISH
37.0	DUTCH
6.5	FRENCH
4.2	THAI
3.6	ALL OTHER
100.0=1,004,429 LONG TONS	

RUBBER PRODUCING AREAS

SHIPMENTS FROM AREA	LONG TONS	PERCENT OF WORLD TOTAL
1	968,536	96.4
2	16,094	1.6
3	14,859	1.5
4	2,861	0.3
5	2,079	0.2

While this map was in the process of being engraved, a change occurred. The black spot on the Amazon, the Ford plantations, were abandoned by the Ford interest and there is small prospect that anyone else will carry them on. The prospect of synthetic rubber in the factory, and the return of the coolies to the plantations of the Far East seemed to promise too much competition. A rubber battle in markets and politics is in the offing.

name "rubber." For eighty years it was used only as an eraser, for which small quantities sufficed. In 1823, a Scotsman, named MacIntosh, used caoutchouc or rubber to waterproof cloth (which yet bears his name), but in hot weather the gum got sticky, and in cold weather it grew brittle and broke. In 1842, Goodyear, an American, discovered that the process of vulcanizing, or mixing rubber with sulfur, remedied these faults, and gave it the qualities so suitable for waterproof clothing, shoes, and boots. His invention started the rubber boot and shoe industry, which has for half a century supplied what was considered at first a luxury for the well-to-do, but is now the common clothing of the ditch digger, farm laborer, miner and lumberjack. About the year 1890, rubber consumption entered upon a period of great increase due to the invention of the pneumatic tire. The sudden development of the bicycle industry promptly followed because of the essential service of rubber. A few years later came the automobile with its still larger demand for rubber in heavy tires. The huge expansion of the automobile industry during the decade 1915-25 caused the rubber industry to expand in like proportion, and raw rubber became one of the staple raw materials of commerce. As a consequence, any rise in crude rubber prices or threat of a shortage or foreign monopoly sets the rubber-using nations of the world (chief of which is the United States) hunting frantically for new sources of supply.

Early Sources of Rubber. Our crude rubber supply has followed the age-old course of man's progression from the hunter to the grower. For over half a century the major part of the world's rubber was obtained from the wild rubber trees found chiefly in the upper valley of the Amazon River. This rubber-yielding forest includes about half of Brazil and those large parts of Bolivia, Peru, and Ecuador which lie east of the Andes and receive the heavy rains brought by the trade winds from the Atlantic. Colombia also has a part of her territory in this basin. A continuous forest stretches throughout the length and breadth of this enormous valley from Pará to the Andes, and reaching beyond it into Venezuela and Guiana on the north and Paraguay on the south stretches. Through this forest man must often fight his way with knife and ax. Scattered here and there in this gloomy jungle are trees of the dozen or more varieties from which the natives gather the rubber to ship down the Amazon.

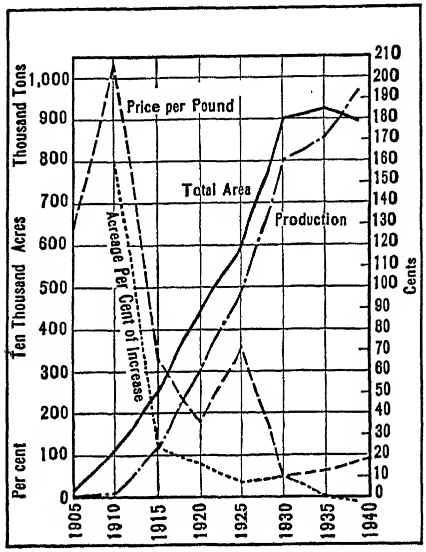
Rubber hunters ascend the river in boats, and after locating a hundred or more trees and cutting paths to them through the dense tropical jungle, tap them for the latex, or rubber milk, which is laboriously coagulated on paddles by smoking it over wood fires in the forest. A paddle that has been dipped in the thick sap is held over the flames, and the acetic acid and creosote of the smoke cause the juice to harden into crude rubber. The process is repeated until a lump of rubber about the size of a man's head is formed on the paddle. It is then ready for shipment to market. Pará at the mouth of the Amazon is the assembling center for all of the wild rubber from the Amazon basin, and has given its name to the finest grade of crude wild rubber. This commerce in rubber and the supplying of the rubber gatherer's wants was for

decades the chief reason for the existence of Pará, the city of Manaos a thousand miles upriver, and Iquitos in eastern Peru, to which small steamers regularly ascend.

The methods of the Brazilian rubber industry are primitive, the product is often uneven in quality, and the facilities for getting the balls of rubber to market are poor.[4] The wild rubber trees of Brazil, Peru, and a few other scattering tropical countries produced over 49,000 tons in 1912 and only 16,000 tons in 1939. Obviously this relatively small amount was entirely insufficient for the needs of the world after the automobile came into general use. Consequently the beginning of rubber culture about 15 years before the arrival of the automobile (in quantity) seems almost providential, if one may assume Providence to have an interest in automobiles.

Plantation Rubber Gets Its Start. The best rubber tree of the Amazon (Hevea Brasiliensis), which requires a rainfall of 80 to 120 inches with the full torrid temperature of 75° to 90° each day, is at home nearly everywhere below 2,000 feet in the equatorial rain belt. In 1876 an English scientist carried seeds of the Hevea from Brazil to England. The rubber trees were grown successfully in the famous Royal Botanical Gardens at Kew, near London, and distributed thence in 1881 to India and Ceylon. The Ceylon trees seeded, and these seeds were sent to the Federated Malay States and the Dutch East Indies. The temperature and rainfall of the equatorial Far East differ but little from that in Amazonia; a Hevea tree in the Malay Peninsula often grows to 60 feet in three years' time.

The transplanting experiment was successful, and rubber plantations, financed by British capital and worked



Production of plantation rubber, percentage increase of area, annual average New York crude rubber price per pound. Per cent of increase and price descend like rockets, as acreage and production ascend like rockets.

The total area is less than that of the state of Delaware and price, going from \$1.60 to less than 10¢ at New York after the rubber had come halfway around the world, is sufficient explanation for the cessation of planting and the actual decline in acreage.

by coolie labor imported from China and India, gradually arose in the Far East. In 1900 the output of the plantations was only 4 tons of crude rubber, while the wild forests produced 54,000 tons; by 1913 the output of the two sources was equal; in 1922 the production of the plantation article had grown

[4] Principles of economics and human nature have been well illustrated in Amazonia. The rubber price slump of 1920 did the same thing to these hungry one-croppers that the boll weevil did in our Cotton Belt—started diversification: corn, rice, timber. The rising price of 1925 and 1940 sent them out again for rubber—but not for long.

to 340,000 tons, while the wild supply had decreased to 23,000 tons, because the market was glutted in 1918 and the price was ruinous.[5] Thus from a few seeds collected in the Amazon Valley[6] have grown the vast rubber plantations in the Eastern tropics, with over 500 million trees and supplying over 96% of the world's needs from seven million acres of land (1939).

Plantation Methods. Numerous changes in rubber methods have come about through the shifting of production from the isolated tree, to which the rubber hunter laboriously cuts a path, to the scientifically managed rubber plantations in which tens and even hundreds of thousands of Hevea trees yield an annual crop. The rubber trees are set out in rows like fruit orchards, usually 12 feet apart, and grow to tapping age in six or seven years. At seven years old the plantation should be in its prime, possessing no tree less than 20 inches in girth. The ordinary plantation produces about 400 pounds of rubber per acre. However, plantings of improved budded stock produce 1,000 to 1,400 pounds per acre.[7] As new plantings arrive at maturity, the average amount produced per acre will increase. At all times the big plantations are confronted with competition from the low-cost native farms and gardens—and this competition has a depressing effect upon the world price of natural rubber.

The contract system of labor is used[8] in parts of the Far East, the laborer, Chinese, Hindoo, or Malay, being imported to serve on the plantation for a period of three years. His contract specifies the hours of labor (usually nine) and the kind of work. The work may consist of anything from clearing forest or keeping down the weeds between the rows of young rubber trees to tapping the trees for the latex.

The plantation method of collecting the latex is primarily the same as in Amazonia. The plantation laborer starts out before dawn in order to complete his work before the heavy midday rains. Passing down a row of trees he makes a few gashes on each with his knife and puts a cup underneath to catch the liquid. About two hundred trees is an average day's work. Later he returns to collect the latex in large pails and carry it to the plantation factory.

The preparation of rubber for shipping takes place on the plantation and is part of the work of the laborer. The latex is mixed with acetic acid and allowed to stand until it coagulates. The spongy substance resulting from this process is then washed and hung up in sheds to dry, or put into artificially heated ovens in places where the climate is too moist to dry it naturally.

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[5] The efforts of the British, by the so-called Stevenson Plan, to apply scarcity economics by crop restriction is an interesting story, partner to Brazilian coffee valorization and various regulations of American agricultural production in the 1930's. See John W. F. Rowe, *Markets and Men: A Study of Artificial Control Schemes in Some Primary Industries,* The Macmillan Co., New York, 1936.

[6] It is rather an interesting fact that in recent years seeds for rubber cultivation have been sent from Ceylon and Singapore back to tropical America.

[7] Almost all horticultural industries depend on this process—get a phenomenal tree, take its buds and/or twigs, graft them into other trees, and get a thousand or a million twig descendants (called a clone) of the original genus tree—orange, apple, rubber, walnut, etc.

[8] In Java the contract system is forbidden by the government, the labor being left free to "float" from one plantation to another.

The smooth, shield-shaped area in front of the operative is devoid of thick bark because it is a place where tapping has occurred for many months, the wide bare space having been produced by the slicing off of a thin layer of bark at frequent intervals. The man is peeling a bit of dried latex off the edge of the bark, preparatory to taking off a fresh slice to start the flow of latex again.

This tree is one of the ten million trees (prewar) on United States Rubber Company's plantations in British Malaya and Sumatra, across the straits.

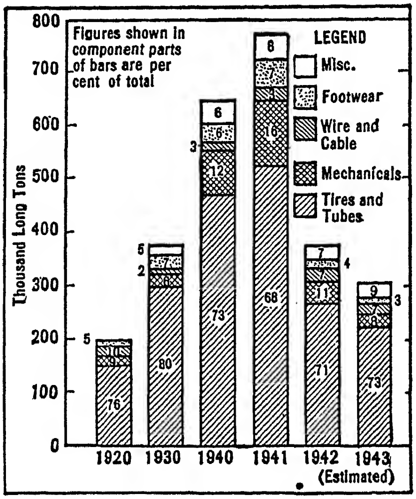
The slow drying process is often combined with smoke-curing similar to that practiced by the natives on the Amazon. This smoked rubber commands a better price, since in the smoking process the rubber is strengthened and preserved by the creosote and other substances in the palm leaves used. It goes to market as "ribbed smoked sheets." Plantation rubber is usually of more even quality, and the curing is better than that of the forest-smoked product. The rubber market of the world has long since shifted from Pará, Brazil, to Singapore.

Latex as it is gathered from the trees has for years been piped into tank ships and transported from Singapore to the United States. Latex is becoming more and more important; and while only 1½ million gallons were shipped to the United States in 1923, over 60 million gallons were imported in 1939, and over 75 million in 1940. Not only has the use for latex widened considerably; it has been found that dry rubber can be prepared from it in the United States.

Present World Sources of Natural Rubber. The world's rubber plantations

today would not cover quite all the state of Maryland.

Table 40 shows where it is, the chief exceptions being Henry Ford's Amazon attempt, reported to be now 200,000 acres, and the Firestone attempt in Liberia—two interesting ventures to watch in the face of the Far East and synthetic rubber.



The United States consumption of crude rubber and latex by major products, 1920, 1930 and 1940-43, shows the towering position of the automobile and the very small fraction required for 30,000 other uses.

The plantations in the Far East are almost without exception owned abroad, chiefly by the British and the Dutch. The French and Belgians also control important holdings. American interests, however, control less than 3% of the acreage, although this country is using two-thirds of the crude rubber marketed.

The Future Supply of Rubber. The United States is the greatest rubber consumer in the world, with a consumption of about five to six pounds per person per year. Since we must buy practically all of this vital material from other countries, most of them on the opposite side of the globe, much attention has been given to the possibilities of devel-

TABLE 40

RUBBER SHIPMENTS, 1922 * AND 1940 †

(In long tons)

	1922	*1940*
British Malaya	248,158	540,000
Ceylon	47,367	89,000
Netherland Indies	72,110	537,000
Brazil	21,735	
Africa	3,205	17,000
French Indo-China		64,000
Thailand		44,000
Sarawak		35,000
North Borneo		18,000
South America		18,000
Burma		10,000
India		12,000
All others		6,000
Total	....	1,390,000

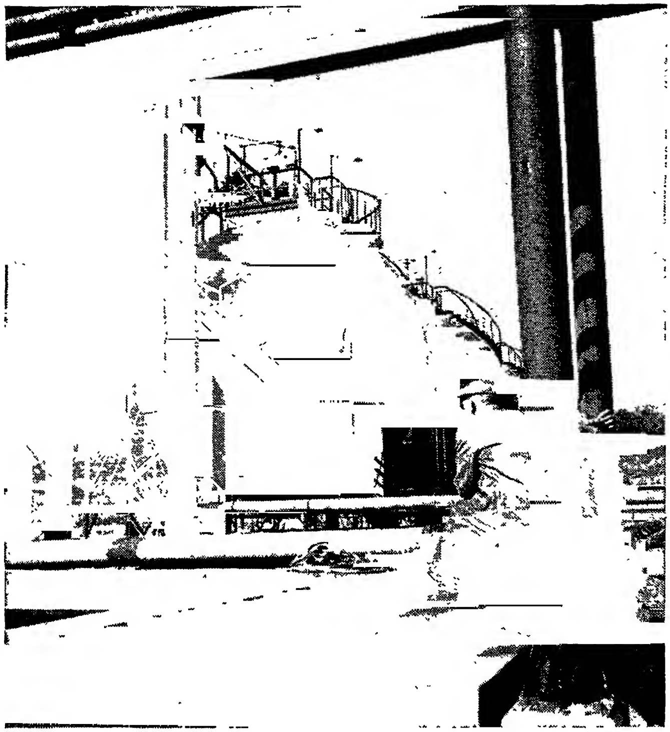
* *Marketing of Plantation Rubber*, Trade Information Bulletin No. 180, U. S. Bureau of Foreign and Domestic Commerce.

† Statistical bulletin of the International Rubber Regulation Committee.

oping new sources in this country and in tropical America.[9]

The first round of this enthusiasm resulted from the British monopoly, by the Stevenson Plan, which checked production and jumped the price unreasonably shortly after World War I. But the real fury began when the Japanese occupation of the East Indies took possession of 90% of our sources of supply in 1942.

[9] A special appropriation was made by Congress in 1923 to investigate the whole rubber situation as it affected the United States. An interesting report was published.



Butadiene, a gas and the chief constituent of buna—synthetic rubber—is stored as a liquid under pressure in great spherical tanks in one of the United States government-owned plants built during World War II.

The United States Government subsidized large plantings of the desert bush guayule in our own Southwest. It spent money lavishly and foolishly in tropical America.[10] But the real attack was in the manufacture of synthetic rubber.

The chemists had been working with that problem for decades. For decades, they had known how to make rubber. The trouble was that it cost too much. Our need during World War II gave the chance to apply mass production, the government poured out the capital, and the miracle happened—7,000,000 tons of factory rubber in 1944.

The almost miraculous capacities of chemical science and industry are suggested by the fact that rubber can be

[10] The *Foreign Commerce Weekly,* September 2, 1943, reported as follows:

"Less than three months after Pearl Harbor, the U. S. Rubber Reserve Company had negotiated an agreement with Brazil for increased rubber production in the Amazon Valley, and a contract was made whereby this agency would purchase the entire export surplus of Brazil's crude rubber. In the endeavor to augment the production of natural rubber, the Rubber Development Corporation (founded 1943) undertook a vast program, including the construction of a number of airports throughout the Amazon jungle, to facilitate transport of rubber and workers—the supplying of equipment and tools to the rubber gatherers—and the instruction of the rubber collectors in the most modern methods of rubber tapping. . . . The rubber purchasing agreement with Brazil extends for five years, and it is expected that under their diversified program rubber production will be increased to at least double the recent yearly output of 20,000 metric tons of which the U. S. will receive all that is not consumed by Brazil's rubber products industry."

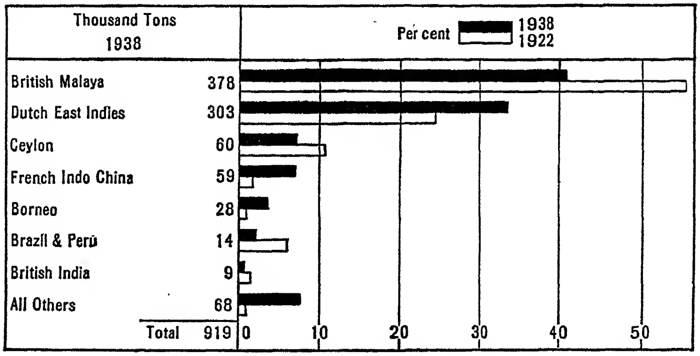
made by starting with (1) limestone and coke, (2) petroleum, (3) grain, (4) wood pulp. The years just ahead will surely witness an interesting struggle—partly economic, partly political—a fight to the death on whether rubber shall come from the factory or the tree.

The two (or 20) rubbers are not exactly alike. If we go in for synthetic as our chief dependence, there will be need with present technology for some natural rubber, and vice versa. From the standpoint of conservation of the world's resources, it should grow on trees. If the market becomes really competitive, there is plenty of room for great expansion of rubber plantations and for their improvement.

Possible New Rubber Areas. As far as soil and climate is concerned rubber growing is very far from being limited to the East Indies. The best possible rubber region as we now know it includes the equatorial rain belt which almost encircles the world. Rubber can be extracted in small quantities from over 200 different plants, trees and shrubs; it could probably be successfully produced by nearly that many different tribes or peoples in South America, Central America, Asia, Africa, and the islands of the sea. But as one of the incidents of the recent past has been the virtual disappearance of wild rubber, in favor of the cultivated variety, the user of natural rubber is chiefly interested in the most favorable spots for cultivation. The rubber tree has been introduced and found to thrive not only in the East Indies but in Northern Queensland, the Fiji Islands, some of the West Indies, the Seychelle Islands in the Indian Ocean, and the west coast of Africa, and there is good reason to believe that it will be as much at home in the forests of the equatorial Congo as in those of the equatorial Amazon. Add to these lands the Amazon Basin, where Hevea originated, and other forested areas in tropic South and Central America, and it is apparent that we have only scratched the surface of our rubber-growing possibilities, so far as land is concerned. With a sufficient world demand there could be a production 50 times greater than the present.

Taking only one area as an example, investigators sent to the Philippines by the United States Department of Commerce brought back the report that vast tracts of land in those islands have a soil as fertile and a climate as suitable as the best of the rubber plantations in the Malay Peninsula or Sumatra. The island of Mindanao, about the size of the state of Indiana, and one of the fertile undeveloped regions in the world, was especially recommended as favorable to plantation rubber development. Like hundreds of other places in the world, the Philippines have every requisite for successful rubber growing except the most important—labor.

Rubber Possibilities in Temperate Lands. Some years ago the late Thomas A. Edison and also the Russians began to search the botanical realms for a rubber plant that might be grown as we grow wheat. Search revealed the goldenrod as a suspect. There are several wild trees that *might* make rubber in the southern part of the United States, but not yet. But when one considers what cultivation and deliberate improvement have done for the sugar beet as a result of Napoleon's search for sugar, we see



World production of rubber, 1922 to 1938. The reduced share of British areas in the Far East is perhaps due in part to the enforced restrictions of the period of the Stevenson Plan, for the restriction of output during which time other Far Eastern rubber growers took advantage of the opportunity. This was much like the experience of Brazil with coffee.

vast possibilities of rubber, if the present scientific era lasts.[11]

We are almost bound to have price troubles, no matter what the source, so long as it is from trees. A low price discourages and a high price booms planting, after which it takes years for the trees to affect the market, during which the market starves. Then for years the trees keep on producing, during which time the market gluts—one of the great troubles of tree crop agriculture.

Cheap Labor the Basis for Natural Rubber Success. While the best rubber trees can be grown nearly everywhere in the rainy tropics, there is a limiting factor—labor. The problem of getting a labor supply which will be skilled, hardworking, and above all *cheap* is the one which is causing all the would-be rubber growers over the world to despair.

The labor supply of Malaya is unique. The Straits Settlements (British) are a few settlements along the Straits of Malacca comprising a small fraction of the land area of the Peninsula. Here the British Government has kept the Malay population in order, so that the Chinese, industrious, quick to seize opportunities, have gone there for the business opportunities in a climate which they can stand better than Europeans, as census figures so glaringly attest.[12] Within a comparatively short distance of Singapore are enormous additional labor supplies that can upon demand be furnished by the millions of China, of Java, of India. The Dutch East Indies have a teeming population of their own. Ceylon, an important rubber producer, has a dense population and, moreover,

[11] See J. Russell Smith, *Tree Crops: A Permanent Agriculture,* Harcourt, Brace & Co., New York, 1929, and U. S. Dept. of Agriculture, *Agriculture Yearbook, 1941,* Washington, 1941.

[12] The British have ruled Singapore Island for generations, but see who lives there! The figures for 1941 are:

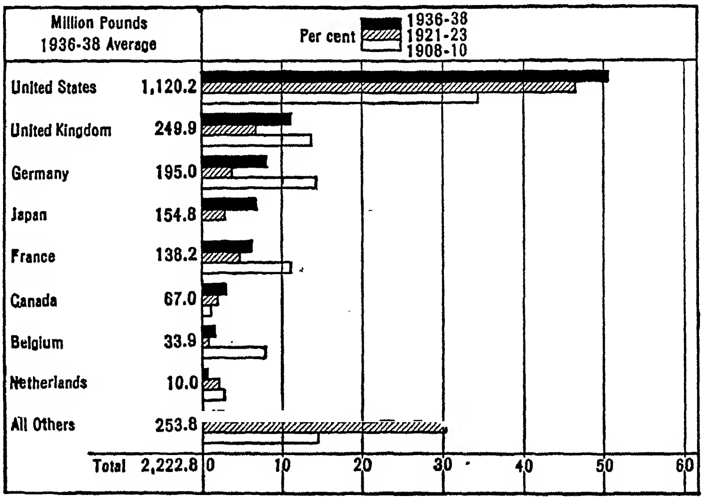
Europeans	18,101
Eurasians	13,540
Malays	315,629
Chinese	927,003
Indians	148,851
Others	12,771
Total	1,435,895

is able to draw tens of thousands of laborers across the straits from India.

It is only too apparent that rubber growing in the British and Dutch East Indies has succeeded mainly because, in addition to peace and order enforced from the outside, they have available a large supply of cheap labor to clear the forest, tend the trees, and gather the latex. In 1938 Chinese rubber workers in British Malaya were paid 23-34 cents, American, per day; women, 20-23 cents; children, 12 cents.[13] This kind of labor supply tropical America does not possess, and the feverish talk of Brazil about entering upon the cultivation of rubber seems destined to poor success unless she imports Chinese laborers into her empty Amazon lands. Africa, South America, and the Philippines, with huge areas of jungle in every way suitable for rubber growing, will be able to compete with Ceylon and the Malay Peninsula only if they can obtain a sufficiently cheap and well-trained supply of workers. The Far Eastern worker and the European manager have taken over cinchona, oil palm, and other tropical plantation crops.

5. *The Manufacture of Rubber*

Crude rubber is a product of the tropics, but its manufacture is largely confined to American and European cities in the north temperate zone, where most of the finished products are used. The art of rubber-making has progressed far since the inventions of MacIntosh (1823) and Goodyear (1842) made possible the first waterproof clothing, shoes, and boots, and modern factories now unite with laboratory skill to give us an ever-increasing number of useful articles. We encounter rubber in the kitchen, in the bathroom, in the hospital, on the train. We wear it on our heads and on our heels and cover



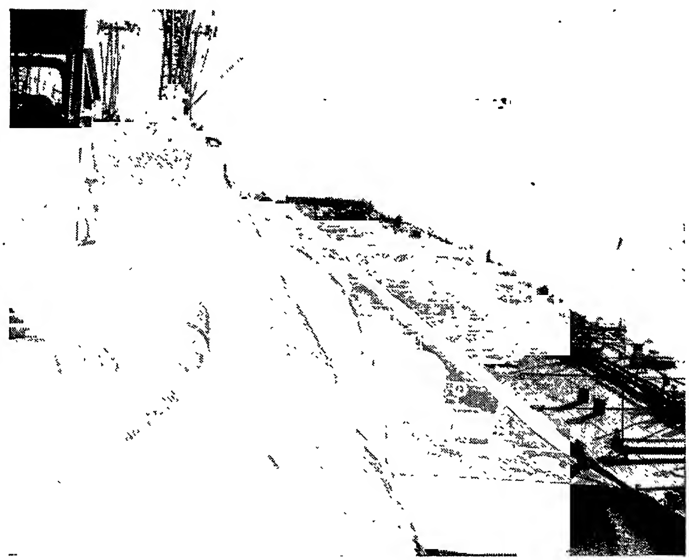
World's rubber import—three-year averages, three periods, quantity last period. In this graph, the wealth of America appears and so does the European wreckage of World War I.

[13] *Straits Settlement Bluebook*, 1938.

ourselves with it in stormy weather. A single concern manufactures 30,000 commodities into which rubber enters, while the inventor is constantly discovering new uses. The equipment of our Armed Forces in World War II included 30,000 articles of rubber, such as tank treads, shock-absorbing and cushioning material in tanks, rubber boats, life rafts, and so on. It is no wonder that the American import of crude rubber has risen from less than 5,000 tons in 1870 to 350,000 tons in 1924, and 650,000 in 1940.

Although the chemist and the machinist now cooperate to turn out such a huge variety of rubber articles, the fundamental process of rubber making still remains practically the same as in Goodyear's day. Raw rubber is mixed with sulfur and then heated to bring about the chemical change known as vulcanization. From 2% to 10% of sulfur is added to make soft rubber, while over one-third sulfur may be added to make the hard rubber used for combs and fountain pens. Certain manufactures such as the automobile tire and rubber hose also use a reinforcement of cotton fabric.

Rubber footwear, the earliest of our rubber products and still a large user of the raw material, is made to a large extent in Massachusetts and other places where leather boots and shoes are manufactured. The industry as a whole, however, was centered in Akron, Ohio, for a time, where an accidental early start plus the development of the automobile industry nearby caused a remarkable concentration, 1900-25. In 1925, the twenty rubber-manufacturing



These huge rubber hoses are used to transfer oil from tanker to barge, or from barge to tanker, according to the circumstances of the port. This picture shows one of the many, many ways in which rubber serves transportation. Without rubber, nearly all of our land transport and air transport equipment would remain motionless due to the loss of tires and of air brakes for the trains.

companies of Akron employed 100,000 workers and used a third of the world's rubber. In recent years, Akron rubber has ceased to increase. Well-organized labor has made the companies so unhappy that they enlarge elsewhere in many eastern cities and on the Pacific coast. Los Angeles, with the large tire market of a state on wheels, is now the second rubber-manufacturing center of the United States.

The use of rubber which at present dwarfs all others is that of automobile tires and inner tubes. The 30-odd million cars and trucks use three-fourths of our rubber, and the whole automotive industry used four-fifths of it in 1939. In addition to the cushion-footed automobile, rubber hose is a universal necessity filling a thousand uses; the airbrake system of every train requires it. Rubber packing in engines, pumps, and valves, and rubber electrical supplies show how universal is the distribution of manufactured rubber, which goes wherever steam goes and wherever water is lifted by the engineer. For these purposes the products of American rubber factories are sent to almost every country in the world.

. . . 22

Fibers, Textiles, and Clothing

It is easy for us of the Machine Age to overpraise ourselves. We do have a vast quantity and a marvelous variety of gadgets, but we should not forget the skill of the unscientific ancients. An expert tells us that the finest weaving in the world was done in Peru before the discoveries of Christopher Columbus brought calamities upon those poor people. The nimble fingers of Hindu spinners twisting a tiny bamboo spindle with a bit of clay upon it to give momentum, spun by hand 253 miles of almost microscopic thread from a pound of cotton to make dacca muslin. Our machinery gives *quantity*.

The clothing of mankind is the product of wide-reaching world industries, which, with the production of the raw materials, touch in varying degrees all countries. A multitude of fibers contribute, but cotton is by far the most important. In the prewar years of 1935 and 1936, as well as in 1942, the United States used nine times as much raw cotton as scoured wool, its closest rival. Because of its commanding lead in cotton-growing, the United States is the greatest factor in the production of raw materials for the world's clothing. The United Kingdom has a similar leadership in textile manufactures, more than one-fourth of her industrial workers (1935) being employed in textiles, while in the United States one-eighth were so employed (1937).

1. The Supply of Raw Cotton

The Universal Use of Cotton. It is probable that few readers of this book ever saw a person into whose clothing cotton did not enter in some part, for it is alike the raiment of princes, in part at least, and of primitive peoples who wear only a simple breech cloth.

Cotton was in extensive and general use in India as much as twenty-seven centuries ago. Unlike most other important plants, its distribution throughout the part of the world suited to it took place at a very early time, probably by natural means, for Columbus, Captain Cook, and other early discoverers found it in general use in the West Indies, Brazil, Mexico, and the islands of the Pacific.

Until the end of the eighteenth century cotton was one of the most expensive of fibers, because hand labor was the only method of separating the fiber from the seed. The difficulty and slowness of this work made cotton more expensive than wool and linen, and caused it to be relatively more expensive than silk now is. In that day "cottons" was the name of a fabric made of wool in imitation of cotton—a process now so diligently reversed. The poor man of 1790 had to choose between wool, linen, and leather, and this last material, in the form of workmen's clothing, played a much more important part in man's raiment than now.

Revolution Through the Cotton Gin. In the year 1793, the cotton gin, invented by the Yankee schoolmaster Eli Whitney, started a revolution in the cotton industry and through it changed the course of American history.[1] Before

This cotton plant has been stripped of its leaves to show the structure, the open bolls ready to pick, and the unopened bolls that are not ready to pick. The latter show the uneven ripening and present one of the major problems for the mechanical picker.

this time cotton production required a most abundant supply of cheap labor to pick out the seeds from the fiber, a day's work resulting in from 1 to 2 pounds of cotton. The cotton gin separates the seeds by a very simple mechanical device in which slowly revolving saw teeth pull the fibers through a comb, leaving the seeds behind. This easy ginning so reduced the price of cotton that it changed from a luxury to a necessity, and a great industry sprang up. Between 1790 and 1890 the import of raw cotton into Great Britain increased 7,000-fold. The greatly reduced price and increased demands shifted the deciding factor of production from cheap labor to cheap land. In 1790 three-fourths of the British import was from the West Indies, and 8% was from Brazil, where populous coast settlements grew and seeded it by hand. By 1890 its production in the West Indies had changed but little and was therefore a negligible factor. Brazil's share had, while greatly increased, dropped from 8% to 2¾%, while the United States, with cheap and fertile land, was supplying over three-fourths of the entire world's supply. The gin and tillage machinery promptly transferred it from the class of garden and hand-labor crops to the class of machine-grown field crops, from a region of cheap labor to one of cheap land, from the populous Indies to the broad fields of the almost empty South. The year before the invention of the cotton gin the American crop was so insignificant that the United States had in a treaty willingly promised to export no cotton to Great Britain, but within less than forty years we were sending Britain over two-thirds of her imports. It was the leading article of American export for many decades, during which it was frequently declared that "cotton is King." While it is not now so relatively conspicuous or so politically dominant, it is still an important export. Some years both before and after World War I, its export value was double that of

[1] The influence of cotton on slavery and of slavery on the history of the United States is an interesting bit of the economic explanation of history.

wheat, flour, and lard combined.[2] In 1940 United States cotton exports ($289 million) were eight times the combined value of wheat, flour, and lard ($37 million).

During the century following the invention of the gin, cotton became the well-nigh universal clothing. It has almost entirely replaced linen, is competing with wool in soft and warm flannelettes and flannel, and it is also very generally mixed with wool in the production of cloth to which it adds cheapness and in some cases durability. Other cotton fabrics such as sateen greatly resemble silk, while mercerized cotton is often sold as silk, so that cotton is being used as a substitute for this more expensive fiber also.

Natural Cotton Regions. Cotton is a woolly fiber attached to the seeds of a shrubby plant and contained in a pod or boll, which at ripening time opens so that the white fiber protrudes in a mass about the size of a small apple. Naturally tropical and sub-tropical, the plant will grow almost everywhere throughout the world between 40° north and 30° south. The northward growth of cotton is limited by the requirement of about seven months of frost-free weather.[3] It also needs a good summer rainfall without too great an excess of rain, a uniformly warm summer without too excessive heat, and bright sunshine. A frost-free season from April 1 to November 1 is thus a necessity. Owing to combinations of geographical and industrial conditions, it is exported as yet from few and comparatively small areas, and thus in its distribution throughout the entire world it gives rise to a great international commerce.

Cotton is like many other useful

Cotton has killed an empire of good land in the South through the continuous winter and summer erosion of the bare land in the one-crop cotton system. The hills in this picture, the Piedmont of northern South Carolina, may last, now that they are in strip rotation of cotton, small grain, usually oats, and annual lespedeza. Each strip is one terrace.

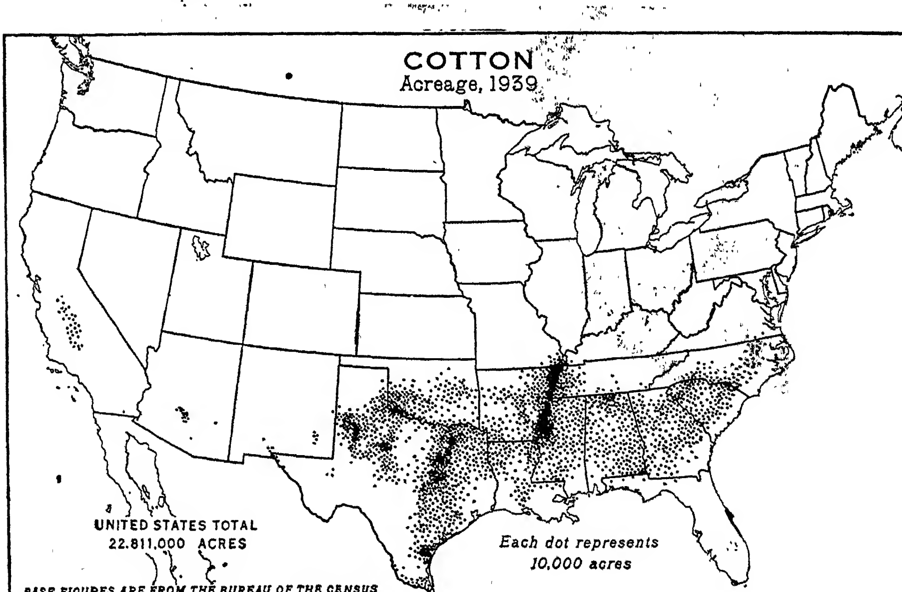
[2] The United States cotton export in 1924 was $950 million, wheat products $328 million, and lard $125 million. In 1931 cotton export was $424 million, wheat $118 million, and all meat products $47 million.

[3] The outer boundaries of cotton production are determined almost entirely by climatic factors. The Cotton Belt has an average summer temperature of 77 degrees along the northern boundary. This temperature appears to be the limit, beyond which commercial production becomes unprofitable.—"The Cotton Situation," *Yearbook*, U. S. Dept. of Agr., 1921.

plants in that it tends to be more productive toward its northern limit. The unmitigated heat and moisture of some tropic locations cause the plant to flourish for years, but the gradual cooling of the early autumn or the drying of arid localities suggests death to the plant and drives it to seed and fiber production. It thus happens that this tropic plant yields most of its harvests under the threat of death by northern frost or arid thirst, while the vast reaches of green humid insect-ridden equatorial lands are almost invariably cotton importers. Thus Mexico, with several thousand miles of tropic coast lines, grows three-fourths of its small cotton crop by irrigation in the northern interior.

Cotton, Slavery, and Cheap Land. The invention of the cotton gin caused slavery, which had been a dying institution and unprofitable for all important industries other than rice growing in the swamps of South Carolina and Georgia, to assume a new importance in the South. The great abundance of cheap land made easy the growth of cotton by slaves under plantation methods. Under this system of one-crop, extensive agriculture, it was the common practice to clear up a forest, usually burn the wood, raise a few crops of cotton and corn, abandon the field, and clear up more land, the ground being cleared in the winter time by slaves who cared for the crop in the summer and picked the fiber in the autumn. Our soil resources have been shockingly wasted by too intensive cotton cultivation in the South under the one-crop system.

Possible Area in the United States. It is estimated that 700,000 square miles of the southern part of the United States has the climate suitable for cotton.



This map shows clearly the alluvial lands along the Mississippi, the black lands of east central Texas, the sand hills of the Piedmont of Carolina, the better clays further toward the mountain, and the irrigated spots west of the Texas Panhandle.

Owing to the ease of injury by too much rain and cloudy weather the coast districts of South Atlantic states are not so well fitted as the districts further inland where the greatest centers of cotton production are found. The small proportion of cotton states actually in cotton at one time shows how the one-crop system still finds room and also shows great possibilities of increased production. In 1879, 20,000 square miles were in cotton. This was practically doubled in 1899 (37,500 square miles). By 1924 it had increased to 70,000 square miles, but decreased to less than 35,000 in 1941, when the government was paying farmers *not* to produce.[4]

Method of Growing. The cotton seeds, about the size of a small pea, are planted thickly in rows from February to May, depending upon latitude. As soon as the plants are established, they are thinned usually with hoes, after which frequent cultivations with the plow or cultivator are needed to keep down the weeds, and during the growing season the plant attains a height of from 2 to 5 feet, produces a beautiful blossom followed by a green pod, which later bursts open, showing the bunch of white fiber.

The picking of the fiber, which has long baffled machinery, is done by hand. Because the cotton does not all ripen at once, the field must be "picked over" several times before the crop is all harvested. The large amount of work involved makes picking the limiting factor in cotton growing. On the whole, harvesting represents the major cost of cotton production, usually amounting to about 20% of the total. Owing to the light nature of the work, much of it is done by Negro women and children. For the past decade the South has shivered over the continuous threat of a successful cotton-picking machine and its consequent unemployment.

The Boll Weevil and Diversification. The ease with which the grower's cotton—indefinitely keeping, inedible, hard to steal, easily handled, and the king of money crops—could be mortgaged and the great difficulty of mortgaging any other crop were factors in the establishment of the great crop-mortgage system in the South both before and after the Civil War. The cotton planter or small farmer obtained credit from his banker or merchant for all necessary supplies and provisions, generally giving a mortgage upon the crop and often upon his team and tools. At the end of the year the crop was turned over to the merchant or banker, who sold it, deducted the advances, and, in theory at least, returned the balance, if any, to the grower. The man advancing the money did not encourage the growth of other crops, nor the development of a more rational agriculture, because no other crop was so easily mortgaged, so easily stored, or so readily salable as cotton. Also, if the grower did not have a garden there was more borrowing. Thus one-cropping was fastened upon the South to an extent where few supply crops were grown and even the hay eaten by the mule was often imported, as was also the mule, from north of the Ohio or west of the Mississippi.

The cotton boll weevil, one of the

[4] Several branches of the U. S. Government diligently teach us how to grow cotton. Another pays us real money not to grow cotton and other things. Please read *Alice in Wonderland* again. It's a good book, sensible too for this age—by comparison.

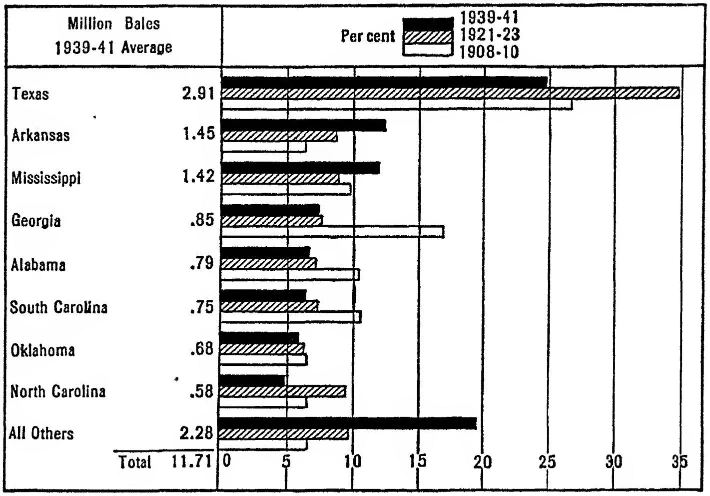
most destructive insect pests known to agriculture, made its appearance in Texas in 1892, coming from Mexico, but its full effect was not felt until after 1914, the year of a record 16 million-bale crop. The weevil lays its eggs in the young bolls, and when the larvae are hatched they feed upon the unopened bolls, causing them to drop off, shrivel up or rot. Within two decades this pest spread throughout the Cotton Belt, costing the South scores of millions of dollars. Bankers and merchants refused to make advances, and the farmer found himself without credit, without food, and without money. The result in many cases was financial and agricultural panic, with farms abandoned, stores closed, and labor leaving the country.

Many of the erstwhile cotton farmers were forced to abandon their one-cropping, plant gardens, raise more corn, and keep a few pigs, cows and chickens in order to live (motto, "Cow-sow-hen"). The South has excellent natural facilities for the growth of forage crops and the development of livestock industries, and although she still continues to import some of her mules, hay and corn, butter, cheese and pork, an excellent start has been made in the direction of home production. The weevil still infests nearly the entire cotton area, in spite of vigorous eradication measures by state and nation, including the use of airplanes for dusting the fields with insecticides. In helping to break up the crop-mortgage system, however, and giving the South a diversified agriculture instead, the weevil has been a great blessing,[5] especially as it is still possible with care to grow considerable cotton.

2. *Important Cotton Districts*

Cotton is grown in nearly every southern county from Norfolk, Va., to western Texas, and up the Mississippi to the corners of Missouri and Kentucky. It thrives on nearly all well-drained soils within this area, but three localities with unusual soil stand out conspicuously. One is the rich, black prairie of Texas. Another is the so-called Mississippi "bottoms," a term chiefly applied to the alluvial land along the Mississippi River between the mouth of the Ohio and Vicksburg, which is occasionally fertilized by the mud deposited when the river overflows its banks and floods the whole region. The third district in which the natural fertility of the soil suffices to give a crop greater than the 1941 average of 231.9 pounds per acre, is in Georgia, North and South Carolina, where two wide belts of fertile clays are separated by a strip of less fertile sand. The destruction caused by the boll weevil in the heart of the old Cotton Belt has had the tendency to push cotton growing west and north to the margins of the weevil territory where the winter is harder on the seed-weevils, and to irrigated areas in California, New Mexico, and Arizona. Texas, the leading cotton state, produced in 1940 over twice as much as its nearest rival, Arkansas. These two states which produced 34% of the crop in 1914, had 53% of it in 1923, and 33% in 1940, after artificial reduction.

[5] One of the strangest monuments ever erected is in the little town of Enterprise, Alabama. The inscription on it is as follows: "In profound appreciation of the boll weevil and what it has done as the herald of prosperity this monument is erected."



The leading states in the production of cotton, three periods by per cent last period by quantity.

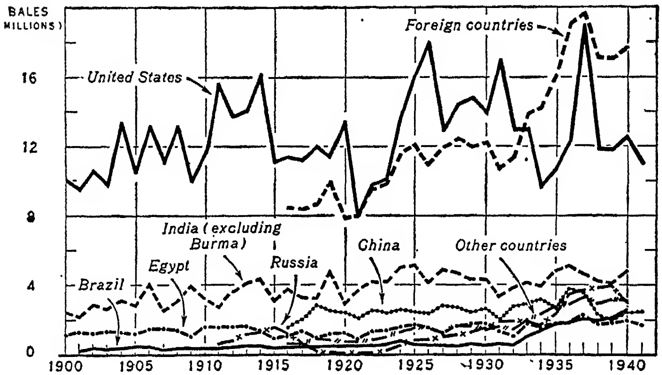
Sea Island Cotton. The fibers of the ordinary upland cotton, the chief product of the United States, vary in length from five-eighths to one inch, but a variety known as Sea Island cotton, considered the best in the world, has fibers nearly two inches in length, sometimes even longer. This fiber surpasses all other types in length, strength and fineness, and commands a high price for use in the manufacture of superior fabrics. Sea Island fiber was long grown on the low sandy islands (barrier beaches) and their adjacent mainlands in South Carolina and Georgia. It seems to require heavy rain, much moisture, and the slightly saline soil and air of shore districts. The West Indies Islands are the other important growers of this cotton.

Sea Island cotton in the United States has proved itself particularly susceptible to attack by the boll weevil, on account of its late-fruiting habits.[6] Production has declined from 116,000 bales in 1916 to almost nothing in a decade. A similar long-staple cotton bobs up, however, in the dry air and irrigated fields of New Mexico, Arizona and California.

Cotton in India. Asia is second to North America in cotton growing, and India with five million bales in 1941 is second to the United States in production. The leading cotton area is located on the plateaus between one and two thousand feet above the level of the sea and lying east of the Western Ghats Mountains in the region commercially tributary to Bombay. The crops depend upon the monsoon rains of summer,[7] which in this section are rather light.

[6] Boll weevils hibernate in dead grass and cotton stubble, about 6% of them surviving the winter. In theory, at least, two boll weevils may have 12,000,000 offspring during the long cotton-growing season. Since boll weevils increase in almost geometric progression (1, 10, 100, 10,000, etc.) and as there are several generations of them each season, Sea Island and other late-maturing varieties are especially vulnerable to damage. The cotton farmer finds it worth while to burn or plow under his fields in the fall and to plant early-maturing varieties of cotton as early as possible in the spring.

[7] "The arrival and continuance of the southwest monsoon with its accompanying general rains is an important factor in the planting and growth

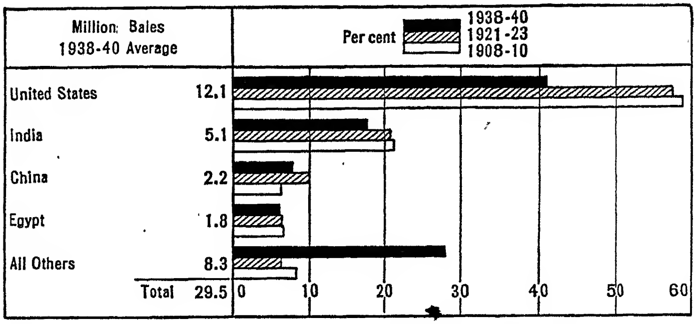


Cotton production in leading countries, 1900 to 1941. The graph for all foreign countries shows an upswing and after we started crop restriction in the 30's the total of all foreign countries is highly significant. We have given away a part of a great export.

Droughts follow rains, and no cotton could be grown at all but for the very peculiar character of the so-called black cotton soil, which in the rainy season is often flooded, becomes a tenacious mud, and after the rains have ceased dries somewhat and is separated by countless cracks into hard lumps. This does not prevent the spongy soil from retaining sufficient water to mature the cotton, which is here sown broadcast like wheat, in a lava soil so enduring that some of it has been planted annually to cotton for centuries. The yield is less than half of that of the United States, and because of the short staple the quality is poorer. The influence of climate is shown by the improvement of Indian cotton when grown in America. Cotton can also survive standing in water in India, but in the Cotton Belt of the United States it is fatal because of the smaller amount of evaporation by which the plants rid themselves of surplus moisture. In northern India, some cotton is grown in the irrigated districts along the Indus and Ganges. The Indian export goes largely to the mills of Japan and China to be made into cheap cotton cloth.

The Chinese Cotton Belt. China was third-largest grower but has been surpassed by Brazil (Fig. 688). Her annual production is not sufficient to meet the needs of her enormous population, whose chief clothing is cotton. A large part of southern China has a climate which is essentially a duplicate of the climate in our own Cotton Belt, and China could easily grow a vastly increased amount of this fiber if her land were not so badly needed for food crops. The areas of greatest production are the Yangtze Valley and the Hwang Valley in the provinces of Chihli, Shansi, Shensi, and Honan. The loose soils of these valleys and also of the Wei Basin of south central Shansi are admirably

of the Indian cotton crop especially in central and northern India. The hot dry weather of the period March to May bakes the soil so that it is impossible to prepare the land for seeding before the coming of the monsoon rains. After the coming of the monsoon, seeding must be completed in the short interval between the first fall of rain and the tropical downpour of the mid-monsoon period."—U. S. Dept. of Agriculture, *Foreign Crops and Markets,* July 30, 1924.



World cotton production, three-year averages, three periods by per cent, last period by quantity. One glimpses the significance of intensity of production by observing the large production of Egypt, a diminutive country, and one having a very heavy population per arable square mile—but don't forget Nile fertility and no leaching.

suited to cotton. The prohibition of the growth of the poppy for opium is increasing the cotton output of China. Cotton also grows over a fairly large area in southern Korea, where it has been a family-supply industry. Under Japanese direction it became a commercial crop. Cotton is also grown to a very small extent in southern Manchuria.

Other Asiatic and European Sources. There is cotton climate from India to Asia Minor and the Straits of Gibraltar, and cotton is grown in scattered spots throughout the region, but most of it is so arid that the small proportion of arable land must be used to grow food crops. Under the stimulus of famine prices during the American Civil War, cotton growing in all these countries rose rapidly to an important amount. Turkey, for example, produced 235,000 bales, but its crop declined to 60,000 bales by 1924, and was raised again to 899,532 bales in 1940, after the United States reduced acreage by law. Cotton growing is important in Iraq (Mesopotamia), and has great future possibilities when new irrigation works shall again rehabilitate the land of ancient empires.

The building of railroads from the Caspian Sea and also from the northwest and north into the oases of central Asia made possible the shipment of cotton, which has been grown in a small way for local use for many centuries. Within two decades after the first railway was built, cotton became one of the most important money crops from the irrigated fields of the oases which are fed by the melting snows of the high mountains of central Asia. Asiatic Russia produced annually nearly one million bales of cotton about 1914, an amount insufficient for the needs of the nation at that time. This central Asian development has a close counterpart in our new cotton production west of Texas. The acreage in Russian Turkestan[8] and Transcaucasia declined in the 1920's. At the present time, however, all

[8] "Cotton production in Turkestan, the most important producing province, suffered almost a total collapse during and since the revolution. Irrigation systems fell into disrepair and marauding bands destroyed dams and drove peasants out of the cotton growing areas."—U. S. Dept. of Agriculture, *Foreign Crops and Markets,* April 16, 1924. Order has been restored. Cotton has returned. The philosophy of Attila the Hun does not agree with irrigation enterprise.

Sovfoto

Uzbek woman picking a very fine crop of cotton not far from Tashkent, in the part of Soviet Central Asia that we have been calling Turkestan. This part of Russia bears great resemblance to our own Southwest, where cotton is being grown by irrigation on the plains at the foot of mountains whence cometh the water.

The description of Utah as an oasis at the foot of the Wasatch (by Mark Jefferson) is a description of all important settlements other than mining towns in large areas of our Southwest. Southwestern Asia and Soviet Central Asia are very similar to this. Recent news items report a plan for a new Russian irrigation canal 245 miles long in this region.

Russian production is estimated from 2.8 to 3.5 million bales a year. Now about 80% comes from Asiatic Russia and 20% from the area around the Black Sea in Europe.

Most of Europe is too far north to raise cotton successfully. Production in southern Europe increased tremendously in the late 1930's. In 1939 and 1940 Greece produced an average of 74.5 thousand bales three times her 1930-34 crop. Italy averaged 58 thousand bales (1939-40), about 23 times her 1930-34 output. Bulgaria grows almost as much as Italy. Minor producers are Spain, Yugoslavia, Rumania, and Cyprus—all thanks to American restriction.

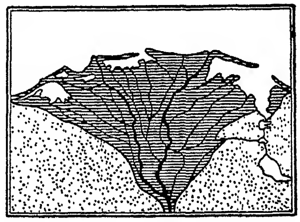
Egyptian Cotton. The Nile Valley of Egypt is without question the best cotton field in the world. The alluvial soil of the Nile Delta, long fertilized by the flood waters,[9] with almost continuous sunshine and warmed by a climate in which there is a steady rise in temperature from spring to summer and a steady decline from summer to autumn, produces about 475 pounds of cotton per acre, which is nearly double the yield of any other country. Unfortunately, its area is not great. The total Egyptian crop is almost two million bales a year, and most of it is long-staple cotton of excellent quality. It commands a high price, and the production which covered 1,350 square miles, or one-seventh of the cultivated area in 1885, increased to 3,880 square miles in 1923, an area greater than that of any other crop and covering about one-fourth the

[9] The fields of Egypt are no longer fertilized by the flood waters of the Nile. All water is under control and the soil does not receive silt as it did during the floods of former centuries.

fields of Egypt; in 1940 cotton occupied 2,733 square miles or one-fifth the cultivated land. The cotton area is limited by the facilities for irrigation, which has been increased since the introduction of modern engineering devices under European management. The greatest of these efforts at cotton extension was the building of the Assuan Dam, which holds back vast quantities of water from the season of flood until the time of need and permits irrigation at all seasons. Flooding of the Nile had annually spread a layer of mud over the Egyptian fields, permitting continuous cropping for many centuries without any other fertilization. There has been complaint from the natives that the fields of lower Egypt are declining in fertility and that the yield per acre has declined since the Assuan Dam shut off some of the floods and the mud. The construction of new dams on the White Nile and the Blue Nile along with the other irrigation projects has made water the limiting factor to cotton acreage.

The variety of Egyptian cotton has been superior to our own for knit goods. However, United States imports have declined from 350,000 bales to 46,200 (1940) within the last twenty years, due to increased production of Egyptian-type cotton in the southwestern states.

Cotton in Our Southwestern States. The long-staple Egyptian cotton is so much desired that attempts to cultivate it have been made in many parts of the world. The nearest approach to Egyptian conditions anywhere (probably) is found in the desert valleys of the lower Colorado basin in California and Arizona, with their long dry season, almost continuous sunshine, and flooding Colorado. In the Salt River Valley of Arizona the construction of the famous Roosevelt Dam transformed some 300,000 acres of desert into a veritable garden, yielding citrus fruits, dates, almonds, olives, 8 tons of alfalfa to the acre, and all the produce crops. Experiments with a variety of Egyptian cotton (called Pima, after an Indian tribe of the Southwest) were especially successful, this cotton under irrigation yielding three-fourths of a bale to the acre. Pima cotton, which is highly prized for its long fiber, fine quality, and pure white color, was first used in the manufacture of tire fabrics, but was later found suitable for various fine textiles. Commercial planting commenced in 1912, and spurred on by war prices cotton cultivation spread into most of the irrigated valleys of the Southwest, but particularly the Salt River Valley and the Imperial Valley of California. Pima cotton rose from 20 cents to a peak of $1.25 a pound, and the 7,000 bales produced in Salt River Valley (1916) grew to 110,000 bales in 1920. The 1921 slump in farm prices checked cotton expansion,



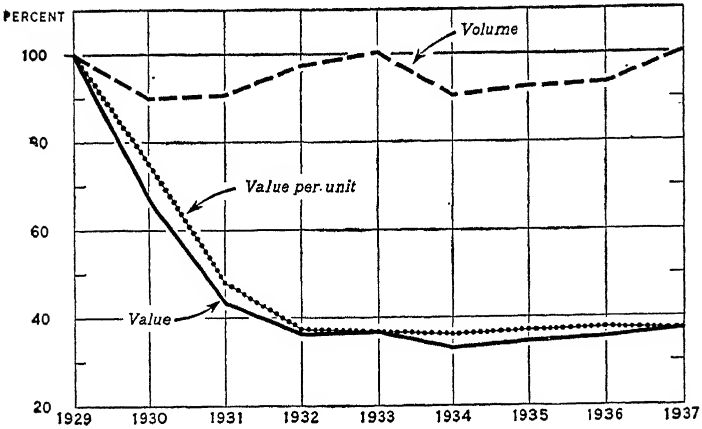
The Nile delta, surrounded by sandy desert, shown in dots—one of four great oases—the others: Mesopotamia, Indus Valley, Imperial Valley of California-Arizona, all very hot, with rich alluvial and desert soil and extremely productive of cotton and many other things.

This triumph of the Soil Conservation Service in Kiowa County, Oklahoma, 99° west, shows how the contour furrows catch the water and give it a chance to soak in, thereby enabling the cotton crop to thrive further west. Note tiny cotton plants. The wide band of water is the drainage outlet for the terrace, which is disposing harmlessly of the surplus of a four-inch rain, which would have cut heavy gullies in that soft light soil even though the slope is slight.

and the farmers who plowed up their alfalfa and sold their pure bred cows in order to plant cotton turned back to the cow and the garden crops. Since 1920 all the cotton planted in California has been upland cotton. While Pima was extensively grown in Arizona, it has now been replaced by S x P, a cross between Pima and Sakellaridis. (Both Pima and S x P are usually termed American Egyptian.) The 1943-44 production was 59,610 bales, two-thirds of which came from Arizona, most of the remainder from New Mexico and western Texas. The price of American Egyptian is more than double that of upland cotton. Yields per acre were well above the national average of 231.9 pounds in 1941; California's figure was 530.7 pounds, Arizona's 401.4, and that for New Mexico was 440.6 in the same year.

South American Production. The early explorers found wild cotton in use among the Indians of South America and sometimes, as in Peru and Mexico, in cultivation. The Portuguese in Brazil soon adapted it to commercial use, and with the aid of slave labor Brazil became one of the world's leading cotton exporters at the end of the eighteenth century. The invention of the cotton gin in 1793 allowed America to displace Brazil in the world trade. In the last century Brazil has been known as a marginal exporter, sharing world markets when areas of cheaper production have been unable to meet the demand—during the blockade of southern ports at the time of the Civil War, periods of drought, disease, or of government crop reduction programs in other areas. However, Brazil now ranks high in world production.

Two areas are outstanding. The former sugar lands of northeastern Brazil account for about one-half the national



World exports of raw cotton and linters, volume and gold value, 1929 to 1937. Index—1929 equals 100. This is another member of the agricultural tragedy family of graphs. When a price goes to 40% something happens. In this case, we tried to restrict production in the United States by legislation.

crop. The types grown are the long, strong-fibered "tree" cotton used in automobile tires, and the short staple similar to United States upland variety which is confined largely to the domestic market. The rest of Brazil's cotton comes chiefly from São Paulo, where coffee and cotton vary in acreage and importance according to fluctuations in world prices and demand. The Paulista cotton is short stapled and competes with the output of the United States Cotton Belt.

Cotton in Peru is an irrigation crop, grown on the arid coastal plain wherever streams from the Andes furnish sufficient water for the fields. The nearby guano deposits provide cheap and abundant fertilizer. Methods of cultivation are no longer primitive. The acreage of native Peruvian cotton with a long, crinkly fiber, highly prized for mixing with wool, or in making imitations of expensive woolen fabrics, has been reduced to 5%. About 10% is the Egyptian type. The white, long-fibered, high yielding Tanguis represents 85% of the crop, which is almost completely exported.

Northern Argentina with its mild climate and moderate rainfall has a large area where cotton growing has proved successful, the crop increasing from 28,000 bales in 1907 to 300,000 bales in 1938. The climate and soil of this part of Argentina and the adjacent parts of Bolivia and Paraguay, known as the Chaco, provide a cotton region far larger than the Cotton Belt of the United States, but the amount under cultivation is limited to a small area that has been cleared of quebracho trees. Venezuela, in the vicinity of Valencia, has some cotton growing, as do parts of Colombia. Efforts have failed to restore cotton planting in Surinam (Dutch Guiana) to the flourishing state it formerly enjoyed under slavery.

The World's Supply and European Efforts to Enlarge It. Of the world's commercial crop, the United States produces over two-fifths, India less

than one-fifth, Russia one-tenth, Brazil one-twelfth, China one-fourteenth, and Egypt one-seventeenth (1940). The great dependence of west central Europe and eastern Asia upon the United States for its cotton supply causes any kind of disturbance of cotton growing or export in the United States to be

TABLE 41

WORLD COTTON CROP

(In bales)

	1922–23	Per cent 1922–23	1939–40	Per cent 1939–40
World...	18,705,000		29,590,000	
United States..	9,761,817	52	12,191,500	41
India....	4,348,000	23	4,466,500	15
Egypt...	1,170,000	6	1,850,500	6
China....	2,048,000	11	2,118,500	7
		92		69
Rest of world..	....	8	....	31
		100		100

sharply felt in diverse parts of the world, and gives an unpleasant feeling of dependence upon this country for the raw material of one of the most important of all industries. During the American Civil War, when the northern states blockaded the South and stopped the export of cotton, the price rose to a dollar a pound and the consequent closing of mills caused great hardship to the cotton manufacturers of Lancashire, England, and other European textile districts. Several times a short production and subsequent speculation in American markets have caused high prices and the shutting down of mills in Europe and Asia. As a result every nation with tropical colonies has made concerted efforts to stimulate the growth of cotton, but the results so far have not been very encouraging, although the possibilities are doubtless very great. Good samples of cotton have been reported from many places throughout the tropics, and the possible areas are extensive. For instance, it has been claimed that the supposedly unimportant Cook Islands in the Pacific have 200,000 acres of cotton land capable of producing enough cotton to feed the factories of a city. A British cotton-growing association tried to increase cotton growing in the West Indies and in Africa and to improve the quality of that grown in India. The French, Spanish, Portuguese, Italian, and Dutch governments made similar efforts, either in their home lands or their colonies. The ultimate results are entirely problematical, but the production in the various British possessions in Africa exclusive of Egypt increased from 10,900 bales in 1905 to over 100,000 bales in 1922-23, and to 352,760 bales in 1940.

Probably the most promising of all the colonial tropical regions is that of Uganda, the Sudan, east Central Africa, and Rhodesia. The potential cotton acreage of Anglo-Egyptian Sudan has been estimated at one million acres, and that of Uganda, together with Kenya and Tanganyika, has been estimated at about 4 millions, and the remainder of the Sudan has considerable potential cotton land. Climatic and soil conditions are favorable over all this area, which contains in places comparatively dense populations of natives who might be converted into a labor supply under European management. Much of this

area, however, will require irrigation and there is doubt whether the headwaters of the Nile will suffice to extend irrigation in the Sudan, without robbing Egypt of her usual supply.

Uganda has 3 million acres of good cotton land, more uniform in character than our own South, and all of East Africa has approximately 60 million acres of such land. (Authority of Dr. H. L. Shantz, agricultural explorer of the United States Department of Agriculture.) The crop of Uganda (75,000 bales, 1922-23, and 310,000 bales in 1940) now makes this British colony second only to Egypt as an African producer. One of the greatest drawbacks is transportation, although many motor roads and some new railroads have improved the situation. The Uganda farmer usually ships his crop to Lake Victoria, where it is loaded on steamers to cross the lake and is reloaded on a railway in order to reach the port of Mombasa, where it can be sent to the world market.

The Union of South Africa has also been paying marked attention to its cotton-growing possibilities.

Queensland, Australia, is said to have much cotton land and has been giving governmental encouragement to the growers, but the fact that the white population is very scanty and that colored races are rigidly excluded makes any large industry impossible at this time.

Probable Improvements in America. The boll weevil gave the industry a great shock, but hundreds of keen minds are fighting him with poison, new varieties of cotton, and natural enemies. With the continued rapid spread of more scientific agriculture, with crop rotation, animal husbandry, and increase of cooperative ginning and marketing in the Cotton Belt of the United States, the economic status of the cotton farmer should be improved and stabilized if he can get a satisfactory price. The invention of a successful cotton-picking machine,[10] for which inventors continually strive, would work a great revolution by removing the greatest labor element in its production and putting it on a par with wheat, oats, and corn, in all of which crops machinery has made possible the production of many acres by a single individual. The cotton gin brought great emancipation to cotton growing, but cotton picking still depends chiefly upon human fingers.

The stimulus to the breeding of early-maturing varieties of cotton produced by the boll weevil outbreak is likely to permit the northward extension of cotton growing in this and other lands. For example, a fairly new undertaking is the growing of cotton in the Crimea, southern Ukraine, and the northern Caucasus. In the period of domestic industry it was grown successfully as far north as Washington, D. C.; every county in Maryland between Washington and Chesapeake Bay, and nearly all Virginia east of the Blue Ridge was producing cotton in 1839, according to the United States Department of Agriculture. The extension of cotton growing 100 miles toward the poles would greatly enlarge its possible production, especially in the United States.

[10] One of the newest of cotton-pickers has moistened revolving spindles which pick 95% of open cotton and do not touch unripened bolls. In advance, weeds are killed, insecticides applied, and a chemical causes the leaves to drop off. It collects enough trash to reduce the value of a 100-dollar bale by 10%; the saving in labor cost is tremendous.

By-products from Cotton. The cotton seed, one of the most nutritious of morsels, was for a long time thrown away, or even burned. Later it was returned to the fields as fertilizer. Then came the discoveries that the oil in which it was so rich could be extracted and put to many and rapidly increasing uses. The manufacture of cottonseed oil is now an important industry throughout the South. Over five million tons of cottonseed are now crushed annually, the crop of 1923 bringing about $32 per ton to the grower, about $21 in 1939 and 1940, and $48 in 1941! A ton makes from 36 to 42 gallons of oil. The oil cake which remains after pressure contains about nine times as much of the important plant foods, phosphoric acid and potash, as does the fiber produced by the plant. It is thus evident that the returning of the seed to the land is an excellent way to maintain soil fertility, but the food value is too great to permit such use. The cheapness and great richness of this cottonseed meal in proteid has led to its appreciation as feed for dairy cows, and it is shipped to every important center of butter and cheese production in the United States and Europe.

For the use of cottonseed oil in place of butter or lard, see the section on Dairy Substitutes in Chapter 19, The Animal Industries. There is no good reason why it should not be more widely used to enrich our bread.

3. Manufacture and Trade in Cotton Cloth

Spinning and Weaving in the Hand Labor Era. Fibers of any sort, including hay, when twisted around each other, tend to cling together and form a thread, string, or rope. Cotton, being kinky and tubular, has unusual spinning qualities. Primitive peoples in every continent have some method of spinning, also devices for weaving. In the rudest or most complex forms weaving is the same as the method by which splints are made into a basket. During most of the Christian era, the material to be spun was held on a distaff, a stick under one arm, and the thread, often twisted by a process like spinning a small top between thumb and finger, was, when finished, wound upon a spindle (Fig. 697). The spinning wheel, used several centuries ago in the Far East, was also independently invented in several parts of Europe in the fifteenth century, was universally used in that continent, and was scattered over the world wherever European colonists went. The thread thus laboriously spun was woven into cloth in hand looms, the industry being carried on in the homes of the workers even when the product was intended for sale. Some people were spinners, others did the weaving, and cloth making for sale was a common household by-industry throughout the western world in the middle of the eighteenth century.

Textile Machinery and the Factory System. In 1764, an Englishman by the name of Hargreaves invented a machine called the spinning jenny, which was the first machine ever used to make more than two threads at one time. This invention promptly sent the spinning wheels to the garret and greatly increased the output of a family of spinners. Four years later Arkwright invented the so-called "water frame" or throstle, a spinning machine which could make the heavy warp thread.

This woman in a cotton mill in Georgia, U. S. A., is tying up a broken end of yarn on the spinning frame. She can tend as many of these spinning units as she can keep tied up. Mechanical power keeps them whirling. To one who has seen the Oriental woman spinning by hand with the age-old distaff, it is not difficult to believe that this woman with her machines is spinning a million times as fast (perhaps it is only five hundred thousand times) as the primitive contemporary ancestress.

In 1779 Samuel Crompton invented the "spinning mule" which was a combination of the machines of Hargreaves and Arkwright and which has been largely used down to the present time. The present spinning mule contains over a thousand spindles upon each of which a thread is wound, and one man can operate two of the machines, making over 300 pounds of thread per day. (The spinning mule is still used in England, but elsewhere the ring spindle, which makes 1½ times as much, is in use.) While the Hargreaves spinning jenny was used in the homes of the old-fashioned hand workers, the spinning mule was best adapted to factories where larger amounts of power could be generated. This power was furnished at first by the water-wheels of Lancashire, England, but steam, which was introduced into English factories about 1790, was soon utilized. For a few years there was a great surplus of thread. The weavers, who had previously been able to use the thread of six spinners and often had to go to the houses of many spinners in the morning to get enough to weave during the afternoon, now found themselves utterly unable to handle the vast quantities of thread which the new machines produced. In 1789,

however, Cartwright invented a power loom which water wheels and steam engines could run, thus enabling weavers to use up the thread. One invention demands and usually produces another. The spinning machine demanded weaving machines, and the weaving machines demanded cotton. In answer to this demand came the cotton gin (1793), six years after the power loom had made cotton acutely scarce. Cotton quickly became cheap. This combination of spinning machines, weaving machines, cheap cotton, and the coal and the iron resources of England, enabled that country to forge rapidly ahead in cotton manufacture while all the continent of Europe was disturbed with the turmoil of Napoleon's wars. In 1785, the export of cotton goods from Britain was worth a million pounds sterling; in 1915 it was 22 million pounds, and during this period it increased from 5% of British exports to 38%. In 1940, while the export of cotton was valued at 49 million pounds sterling, it represented only 11% of total British exports, and Britain felt textile competition from many quarters.

That short period of thirty years between 1785 and 1815 produced greater change in British industry than many previous centuries had made. It has been well called the Industrial Revolution, and, like inventions, machines, and styles, it has spread and is spreading to many countries. Before this revolution, man used little artificial power, and the manufacturer often lived in the village or in the country where he gardened, kept some livestock, and worked on nearby farms. He was near to the food supply and had opportunity to use his extra time to good advantage. Industry was organized around a man's time. After the Industrial Revolution, the worker found himself living in a city tenement to be near some other man's steam-driven machine in the big fac-

TABLE 42

MILLIONS OF COTTON SPINDLES IN THE WORLD

	1900	*1912*	*1923*	*1936*
Great Britain	45.5	55.3	56.6	42.3
Rest of Europe	32.0	43.0	44.7	49.8
Total Europe	77.5	98.3	101.3	92.1
United States				
Cotton states	4.3	11.5	16.5	17.8
Other states	15.0	19.0	20.9	11.2
Total U. S.	19.3	30.5	37.4	29.0
British India	4.9	6.1	7.3	9.7
Japan	1.2	2.1	4.9	10.6
China	0.5	0.8	2.6	5.0
Canada	0.5	0.8	1.4	1.2
Mexico	0.4	0.6	0.7	0.9
Total world	105.6	141.0	157.8	153.1

COTTON MANUFACTURED

	Pounds of cotton consumed per capita	
	1922–23	*1937* *
United States	27.7	20.9
United Kingdom	29.0	26.5
France	13.2	13.4
Germany	8.4	8.1
Switzerland	13.6	14.8
Spain	8.1	3.1
Japan	19.7	16.6
Italy	11.2	7.3

* Imperial Economic Committee, *Industrial Fibers*, London, 1939.

tory. Industry was organized around a machine, *a machine's time*. Man was away from the earth, the one great resource. He had no chance to produce food in his odd moments and was dependent upon the factory wage and imported food. As a result Britain's people have suffered some physical degeneration and probably other kinds also.

It is entirely erroneous to think of the machines of modern manufacturing as having completed their evolution. Mechanical improvement is going forward as rapidly now as ever, and to this improvement the textile industry is no exception. Between 1904 and 1939 the number of textile workers in the United States increased 54%, and the value that they added to the raw material increased more than seven times. As this was a period of decrease in the hours of labor, the increased result is plainly due in large part to the machinery.

The completed modern cotton mill is large and often costs over a million dollars. In the United States most of the cotton establishments are integrated mills where cotton is not only spun into yarn but is also woven into cloth and often finished (that is, printed, dyed, or bleached). It is still characteristic of the manufacturing industry of the United Kingdom that the yarn is made in one place and the cloth in another, as was done in the days of the wheel and hand loom.

Present Distribution of Cotton Manufacture. During the nineteenth century, textile machinery has been exported to many countries, and cotton cloth has traveled to the ends of the earth. The spinning wheel has disappeared before steam-borne commerce in ever-widening circles, until now it lingers only in exceedingly remote locations, where it continues, not because it is impossible to transport cotton cloth, but because it is impossible to send out any product with which to pay for it.[11]

Britain's early leadership and dominance in cotton manufacturing, as shown by her leadership in the number of spindles, cotton consumption, and export of manufactures, persisted until the last two decades when the textile industry began a steady march to other lands. This was greatly promoted by World War I and the price slump in raw materials in the 1930's.[12]

Relation of Cotton Manufacture to Density of Population. The world's cotton mills produce many varieties of cloth, from the coarsest to the finest, and the distribution of the factories making different kinds is an admirable illustration of the effect of dense popu-

[11] Homespun cloth is still made in native hand looms in some remote parts of Africa, the Andean districts of South America, and large parts of Asia. Japan has emerged from the hand-loom epoch. The Chinese are, in many cases, still clad in homespun. In the United States, the old method is found in the heart of the Appalachian plateaus of eastern Kentucky and western North Carolina, and numerous efforts are being made to perpetuate the almost lost handicraft. Weaving is now becoming a recreation to the mechanized housekeeper in some American homes. They say that hand-weaving is a solace and has charm—as men speak of golf.

Of interest is the existence of the domestic system in Europe itself. Ireland is reported to have 386 women lace makers. From the Donegal peasant women's looms comes homespun cloth, much prized for its texture, figure and homemade vegetable dyes.

[12] Shylock said he'd have his bond. The British investor said he'd have his interest paid in gold. Australia, for example, had nothing with which to pay her vast interest to Great Britain, except meat, wool, butter, cheese, wheat. Their prices went to almost nothing, barely enough to pay interest, nothing much left to buy imports, so they proceeded to levy tariffs against the United Kingdom, and British trade suffered an almost mortal blow. Could you find a better argument for the commodity dollar?

lation upon manufacturing industries. A pound of raw cotton may, with much fabrication, become several dollars' worth of the best machine-made lace, or it may become a yard or less of coarse, heavy cotton duck. Several times as much labor and capital are required to produce the finer of these two products, even if machine made, while if the lace is made by hand it takes vastly more labor than that required for machine lace. Brussels has been the center of the world's hand-made lace industry for the natural reason that it has been the metropolis of the most densely peopled nation of Europe. Much of the lace is made of fine linen thread by the Belgian peasant women in the intervals of their farm work—a means by which they retain the great advantage of the domestic system—steady employment.

Britain's early monopoly in cotton manufacturing has given way, due to the rise of the industry elsewhere, as on the continent of Europe, in the United States, Japan, China, India, and Brazil, which regions were in the past the chief British markets. As country after country has taken up the manufacture, it is the characteristic of new cotton industries to start with a coarse, cheap, general utility product. Britain has been able to continue her textile manufactures by specializing in high-grade, expensive, finely woven fabrics which necessitate skilled labor. While the product enters a more limited market, this is partially offset by the higher selling price.

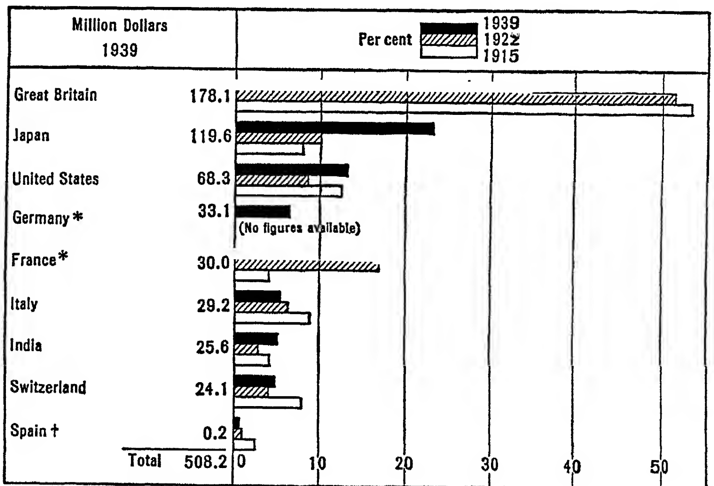
The United States has an instructive distribution of the industry into regions of general utility and specialty production. Cotton manufacturing had its origin in New England; today high labor and production costs allow only the manufacture of first quality goods carrying the skill, name and reputation of outstanding weavers. The newer Southern Appalachian area with its cheaper operating costs now leads in the manufacture of general and low-grade cotton materials.

British Cotton Manufacture. For more than a century the name of Manchester has been synonymous throughout the commercial world with cotton cloth. That city, the metropolis of Lancashire, long was the center of the greatest cotton-manufacturing district in the world. The industry, established there as early as 1640, was partly due to the Atlantic winds which gave the moisture necessary to the best cotton manufacturing. Later these same Atlantic winds influenced the industry through the water power of numerous small streams that descended from the central highlands (known as the Pennine Chain) and led to quick development after the invention of the new machines. Both of these advantages have now passed away. The moisture, like the temperature of the factory air, can be controlled, and the factories of Lancashire have long since outgrown the water power and turned to steam, for which the local coal fields are very convenient. The third factor in Lancashire's start was the convenient harbor of Liverpool, which has long had wide ship connection with regions producing and consuming raw cotton. The city of Manchester itself has now ceased to be so strictly a manufacturing city, and has become the sale and storage center for the product of many surrounding towns. Liverpool, the natural port of entry for this region, is one of the greatest cotton ports in the

world because back of it lies the great cotton-manufacturing district. It is, indeed, surprising that in a century and a half, the British cotton industry should have spread so little beyond a radius of 40 miles from Manchester. This district manufactures nine-tenths of Britain's cotton textiles, 51% of which were exported in 1938. The intensity of the industry has given to Lancashire seven times the population of Rhode Island although its area is only 8% greater. A son often succeeds to his father's place in the mill, and the skill of the Lancashire operative may well be said to be hereditary, with factory work and school dividing the years of youth.

Great Britain had led all countries in the manufacture of cotton goods because she had the great advantage of an early start, no wars on her home soil, the ready use of capital while others had to borrow, the most wide-reaching shipping connection, and the local advantages of unrivaled coal, iron, and harbors. Because of her tariff policy, she had cheaper food than any continental country, and she had cheaper cash wages than America. As a result of all these advantages, the equipment and also the operation of a cotton mill was much cheaper in Lancashire than in Massachusetts. Hence the United States like many other countries, places a tariff against the import of foreign cotton goods.

However, the British cotton-manufacturing industry which reached its peak before World War I has declined, due to competition from newer areas, and the fact that former outstanding advantages no longer are important. Her early start now means antiquated machinery and inefficient organization, resulting from the industrial disease called conservatism. It is almost endemic in the third generation of successful families. Artificial humidifiers can



* 6 months; † April to December.

Exports of cotton manufactures, per cent three periods, value one period. Note that France and Germany are only for six months in 1939. This graph might almost be called the "Handwriting on the Wall" for Britain's textile export trade.

moisten the driest of air. Inventions and mechanical improvements lessen the significance of skilled labor. Power may be transmitted from distant areas to make fuel deposits unessential. Only by abandoning general cotton manufacturing, and specializing in high-grade textiles has Britain been able to maintain an important position in the world picture.

Great Britain sends fine cottons into the best cotton-manufacturing districts of the United States and of northwestern Europe, and all kinds of cottons to the Scandinavian and Mediterranean countries. Her cloth goes to every colony in Africa, to the countries of western Asia, to the East and West Indies, to Central and South America, Australia and Polynesia; in fact, to the islands, colonies, and non-manufacturing countries everywhere. The total British exports of cotton manufactures, $850,000,000 (1923) compared favorably with the total foodstuffs exported from the United States, $1,050,000,000 (1922). In 1939, exports of British cotton manufactures were $224,424,000; export of foodstuffs from the United States was $313,210,000.

Continental Cotton Manufacture. The continent of Europe has more spindles than Great Britain. Owing to the coarser product produced, there is an even greater relative consumption of raw cotton. Bremen, Le Havre, Genoa, and Barcelona, are the chief importing points, and the greatest center of manufacture lies between the Elbe River and Paris, the North Sea, and northern Italy. This district includes northeastern France where Lille is the leading cotton mill center,[13] and the populous Rhine Valley with a host of manufacturing towns in Germany, Holland, Belgium, and Switzerland, in all of which fine cottons are made for home consumption and for export.

Russia, which had about 9 million spindles before World War I, lost about one-fifth of her former productive capacity to the newer states which were formed. At present there are supposed to be almost 10 million spindles, and consumption is estimated at 3 to 4 million bales annually. Poland fell heir to numerous Russian and German spindles when the country was reunited after 1918. Cotton spinning was its leading manufacture and had centered at Lodz with its millions of spindles, often spoken of as "little Manchester." The cotton mills were restored, and but for the disturbed conditions in central Europe and the artificial tariff barriers raised by other nations, Poland would have had a profitable export. In populous Bohemia, a part of Czechoslovakia, the busy spindles and looms, working on imported materials, made cotton and woolen manufactures the first export in value before World War II, exceeding iron and steel, and glassware. We may expect revival in both Poland and Czechoslovakia.

In Spain, which imported 447,000 bales in 1935, 532,872 in 1942, the chief manufacturing district is Barcelona. Genoa is the chief cotton-importing port of all south Europe, because it receives

[13] The cotton-spinning industry of northern France was greatly damaged when the Germans overran this section of France and occupied it for several years during World War I. The industry has benefited; the machinery removed or destroyed was replaced by new installations of the most modern and improved type. And then came World War II. It is difficult to say what this area and the Ruhr Valley will produce in the next decade.

Pawtucket, Warwick, and Woonsocket in eastern Rhode Island and Lewiston at the falls of the Androscoggin in Maine. Many mills which started with water power grew so large that steam was later used.

The leading cotton-manufacturing city[14] in New England is New Bedford, Mass. Being at the head of a bay, it can take advantage of ocean transportation for the delivery of cargoes of cotton and of coal, which now drives practically all the machinery of the city, the water power having long ago become insufficient for the many mills.

The New England textile labor situation has been typical of many American industries. The people of New England, after a century's experience as textile workers, were skilled operatives, but the industry no longer depends upon native stock. Within recent decades large numbers of French Canadian workers have come from Quebec to the mill towns of New England to find employment. Latterly large numbers of Europeans have come also with the result that mill towns have many languages.

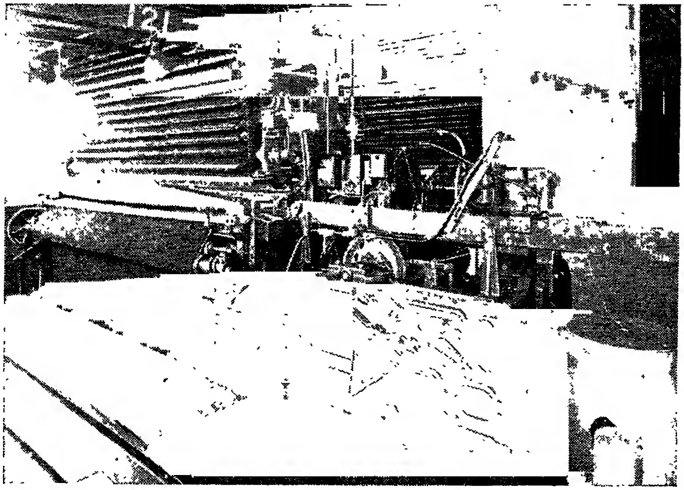
Similar to the textile industry in Lancashire, New England's cotton manufacturing has declined. Here, too, the early advantages are outweighed by more satisfactory economic conditions in other areas—lower taxes, cheaper land and labor costs, modern machinery, proximity to source of raw material and markets, and, finally, grandsonitis, or the inbred ideas of management that have failed to change in response to new conditions in business, and other psychological disadvantages of being born rich. Find a firm 75 years old and bearing the name of the founder. Are his grandsons managing it? Rarely. Many mills were expanded and reopened in New England during World War II to meet the unusual needs of the emergency. Even before August, 1945, however, plans were being made to discontinue operations in many mills, the machinery to be sold here or abroad, or the entire plant to be moved south.

Southern Cotton Manufacture. The cotton-manufacturing belt of the southern states is located near the Fall Line which marks the boundary between the Piedmont district and the Atlantic Plain, and also in the Piedmont district, where it has been able to take advantage of many waterfalls. In Alabama it is close to the coal fields. Its nearness to the raw product which is often grown in the immediate vicinity is an advantage in selling cotton goods in southern markets.

It was the cheaper labor that was one of the chief factors in locating cotton manufacture in the South. The Appalachian Mountain district had a white population, dense in relation to the resources, and therefore with inadequate opportunity for employment, so that wages were much lower than in the North and West. When the cotton mills gave an opportunity for profitable employment these mountain people and the families of sharecroppers migrated in large numbers to the mills just as the people of Quebec and Europe migrated to the mills of New England.

In these localities, where agriculture

[14] Thomas R. Smith, *The Cotton Textile Industry of Fall River, Massachusetts*, pp. 163, King's Crown Press, New York, 1944, gives the record of the amazing ups and downs of an industrial center in the flux of the Machine Age.



This weaving machine is a bit more complicated than that of the young lady in Bali (see next picture). It is a carpet loom made in Massachusetts, cost about $15,000, weighs several tons, but will make about 16 feet of cheap carpet per hour.

with its low wages had been the only industry, and with an abundant supply of cheap labor, the cotton manufacture of the South increased with great rapidity. Other advantages responsible for the leadership of the Southern Appalachians in United States cotton manufacturing are lower living costs, cheap coal, hydro-electric power, local raw material, beneficial land and tax arrangements. Between 1880 and 1940, the spindles increased from ½ million to 17.6 million, and the cotton consumption from less than 200,000 to 6.6 million bales. The mills of New England have been greatly surpassed in the amount of cotton consumed, number of spindles, total value of product, and total wages paid. Greenville and Spartanburg, S. C., are the principal centers.

The South, with its product of coarser cotton sheetings and clothes, products requiring a large amount of raw material with a small amount of labor, entered more largely into supplying our exports than has any other district. Staple and average grade cottons rather than specialties represent the bulk of southern output. Our best cottons tend to stay home, and our export is consumed in largest quantities in countries where, like China and Africa, the coarse cloth is desired by a poor population. China alone has in some past years taken the greater part of our entire export of cotton goods, and we furnish the scanty raiment (loin cloth, 3 x 10 feet) for some of the tribes of Africa.

Cotton Manufacture in Other Sections of the United States. Many British textile workers have settled in Philadelphia, and their skill helped to make possible the introduction of textile industries that had not previously flourished in America. Philadelphia is the chief center of cotton manufacturing in the Middle Atlantic states, the leader in the production of tapestries, chenilles,

and other cotton goods that require skill in coloring. This city also sells machine-made lace, hosiery, and knit goods.

The dependence of the textile industry upon labor more than any or all other factors has caused the amount of cotton manufactured west of the Alleghanies to be very small, and it is not increasing very rapidly.

The Extension of Cotton Manufacture. Cotton manufacturing is an industry which many countries are trying to foster by high tariffs. Brazil is an example. Rio de Janeiro, São Paulo, Pernambuco, Minas Geraes, and the Federal District have large cotton mills with over 3 million spindles, run by water power developed where streams come down from the plateau. Cotton weaving has become Brazil's second leading manufacturing industry, 250,000 people being employed in more than 500 factories. In addition to supplying almost all of the textiles consumed at home, Brazil exports cotton goods to Argentina, Uruguay, Paraguay, and South Africa. In 1942 Brazil's cotton exports were valued at $44 million. For Great Britain this fact is little short of appalling. A number of small cotton mills are scattered throughout Latin America, as at Lima in Peru, in Venezuela, Argentina, and in towns on the east edge of the plateau of Mexico.

It is often the case that the cotton factories of new districts are built by capital, equipped with machinery, and staffed by foremen from an older cotton district. The mills of Carolina and Georgia are often branch enterprises of New England companies. The mills of Mexico are largely French. A British company owns one of the largest mills of Venezuela at Caracas. The textile industries of Italy and Spain even are largely British property.

The prospects of increased cotton manufacture in the Orient are manyfold greater than in tropic America or Africa. The people of tropic America are too few. The peoples of Africa are too little used to industry, but the half of the human race that lives in eastern and southern Asia has the patient diligence born of centuries of labor, and the density of population makes them welcome factory opportunity. In 1880, India, with its millions of cotton wearers, took about one-half of British exports, but since that time the import has declined as a result of the introduction of cotton mills built by British capital, equipped with British machines and directed by British foremen teaching the cheap laborers of India.[15] The mills of India use mostly home grown cotton, only 15% being imported from the United States, Egypt, and East Africa, chiefly of the long-staple variety which is not grown too successfully at home, and which she needs for mixing. The Indian exports of cotton piece goods in 1938 were 27% of her imports; in the same year her exports of raw cotton were 5 times her imports, and the export-import of twist and yarn balanced. Indian cloth, thread, and raw cotton are sent to China and Japan. Since 1933 the Indo-Japanese protocol regulated the imports of Japanese piece goods and the export of Indian raw cotton, to maintain a definite ratio. During World War II, the textile industry has flourished in India and manufacturers hope to hold the position

[15] In 1926 the writer went through a cotton mill in Bombay that did not have a single non-Indian member of personnel.

after the war. There were in 1922, 285 cotton spinning and weaving mills, which employed 307,000 workers, while cotton employees of the United States numbered 425,000. In 1940, 388 mills in India employed 430,000, while cotton employees of the United States numbered 485,519.

The example of India has been duplicated in Japan. With her small amount of arable land and dense population, Japan had of necessity turned to manufacturing. Cotton cloth is her leading industrial product, Osaka the center of the industry. She has imported raw cotton from Texas, China, and India, and her more than 10 million spindles have been turning out large quantities of the cheaper cotton goods. While Japanese labor is said to be efficient, the average wage for Japanese textile workers in 1924 was 1.40 yen (70 cents) a day, and the Japanese millhand works a sun-to-sun day, with few holidays; in 1940 female cotton-spinning textile workers averaged .95 yen a day, including payments in kind and bonuses. Consequently, Japan, with her new machinery and inexpensive second-hand equipment from bankrupt New England mills, her long hours, and cheap labor, was able to manufacture the low-grade cottons to better advantage than either Great Britain or the United States, and was even underselling Britain in India and America in the Philippine market. By 1923, Japan had passed the United States in the value of cotton goods exported, and was second only to the United Kingdom.[16] In the 1930's Japan came to lead all nations in the total value of cotton textile exports. Indeed, in 1938 Great Britain imported £400,390 worth of Japanese cotton goods! In fine quality goods Japan was unable to compete with either of the older cotton-making nations, even for the Japanese market. But as Asia uses very little in the way of fine cotton

Miss Dayoe Poetoe Djegeg, a high caste young lady of Bali, Netherlands East Indies, does a bit of weaving in the old, old-fashioned way.

goods, Japan may become the cotton manufacturer for the whole of the Orient.

China, with her coal, her iron ores and her millions of laborers, has followed Japan's lead in a general as well as a special sense. Mills at Shanghai, Hangchow, Nanking, Tientsin, Tsingtao, and Tsinan, are operated by companies using British machines, American engines, Japanese coal. The cotton factory epoch

[16] The British dependence upon the export of textiles and the stagnation and unemployment in British industry for years following World War I were omens of the decline of British textile leadership and emphasized the peril of the world when we are all dependent upon international trade.

in China is beginning—the spindles now reported, 5 million, being 12% of the British number, but the use of machine goods has rapidly increased. Small factories have been opened in the far interior of China to absorb the cotton produced in their vicinity and supply some of the local demand for yarn and cloth. The enormous Chinese resources of coal, iron, and labor become profoundly significant when it is remembered that the high value of the raw material permits cotton to be taken halfway round the world for manufacture and then taken back for consumption.

Cotton and Cotton Goods in Commerce. Cotton, the greatest staple of the world's clothing, gives rise to much commerce. Formerly no important cotton-manufacturing country except the United States produced enough cotton for its own use, and consequently we sent it to nearly all the manufacturing countries. Even the United States imported foreign cottons because they possessed qualities not found in American cottons.

The trade dislocations of 1914-18 taught a sharp lesson to those countries that could not produce textiles, for in many cases they had to go without. The last decade or two has brought profound changes in cotton culture as well as textile manufacturing. New areas of both have become significant and change the world picture of the industry. Textile manufacturing has become important in India, China, Russia, and Brazil, and others may soon follow. Raw materials, large domestic markets and labor supplies, ready capital, trade treaties, protective tariffs, and government subsidies have been instrumental in the rise of new areas. The dominance of the traditional leaders, the United States and Great Britain, has been broken; their leadership is threatened. Cotton goods are one of the most universal staples of import. They are made in such great variety that they are imported by all countries, whether they are in the stage of breechcloth, sombrero or silk hat. Cottons, indeed, tend to be relatively more important in the breechcloth stage than in any other, comprising, for instance, nearly one-fifth of the imports of Sierra Leone in 1939.

4. The Wool-Manufacturing Industry

Wool and Its Qualities. Wool was originally the under coat of the sheep. Many animals have an outer coat of coarse hair with a shorter warmer coat under it. The seal skin of commerce is such an under coat. On the sheep this under coat has the character we call wool, and by long breeding and selection sheep have come to have their chief coat of wool, although this animal also has some hair and in some hot countries it has hair only, like a deer or cow. Wool differs from hair and other fibers in being crinkly or curled, so that it makes an elastic cloth, and also in being covered with minute scales, whereas hair is smooth. These scales overlap each other as do shingles on a roof, and when the natural grease is scoured from the wool, the scales catch each other and hold the wool together as a tangled mass. This quality is utilized in making a matted threadless fabric called felt, produced by beating, shaking, and rolling the fibers together. This felting process is also used in making hats, both soft and hard.

Woolen clothing is the best for cold climates because it prevents the escape of heat of the body, permits the moisture of perspiration to pass through, and yet does not become wet so easily from rain as do fabrics made of other fibers.

The Process of Manufacture. The fleece as it comes from the sheep has impurities which amount to as much as 75% of its total weight. Chief among these is the grease which exudes from the sheep and serves to make the wool waterproof and also keeps it from felting on the animal's back. Other impurities in wool are dust, sand, burrs, and other seeds of plants, which, in combination with the differing qualities of the wool from many varying breeds of sheep and the differences resulting from food, especially food shortages, soil and climate, give wool an almost infinite number of commercial varieties, greatly complicate its manufacture, and make wool buying a highly specialized task. The process of preparing wool for use consists in washing it to get rid of the loose dirt, scouring it to remove the grease, combing and carding it to get rid of other foreign substances and to lay the fibers out straight ready for spinning the yarn for the final weaving into cloth. In its relation to household industry and the Industrial Revolution, wool manufacturing is like that of cotton and the other textiles, except that it is older and much more widespread. The wool industry has one by-product. The grease, long wasted, is now used for many purposes, including soap, lubrication and oiling leather. Called lanolin, it serves as an ingredient of salves and hair beautifiers—same old job for lanolin.

Woolens, Worsteds and Shoddy. The term "woolen goods" as used in the trade, includes only those woolen fabrics which do not show upon their surfaces the intertwining threads of ordinary woven goods. Woolens are woven, but the fact is hidden by a process called "fulling" in which the cloth is beaten to give a felting effect and finally the fibers are pulled up by being gently combed with teasles so that the surface has a uniform, smooth, almost furry appearance. The chief woolen fabrics are broadcloth, cashmere, tweed, blankets, flannels, and shawls. "Worsted goods," made of woolen yarns, show upon their surfaces their woven origin and are gaining in popularity over woolens. "Shoddy" is thick, warm cloth made of re-manufactured wool fibers obtained by tearing up tailor's clippings and woolen rags, mixing them with new wools, and weaving all into a warm cheap cloth. The demand of the English shoddy mills for wool rags is so great that in 1939 England imported £421,337 of woolen and hair rags from France, the United States, Belgium, Egypt, Holland, Germany, and Scandinavia, plus £106,021 from members of the Empire.

European Wool Manufacture. Flanders was in the Middle Ages the great leader in wool manufacturing. The fertile, well-tilled Rhine delta gave a good food supply for villages of manufacturing people, and canals, rivers, land routes, and sea routes made easy the distribution of the goods produced largely from imported wool, then the staple export of England. The English kings introduced Flemish weavers into England during the eleventh, fourteenth and fifteenth centuries, but for a long time unfinished English woolen cloth went to Flanders to be finished and

dyed. This practice seems to have ended about 1650, and England has now surpassed her old teacher, Flanders, in quality of output. English woolen cloths have been much famed during the period since power-driven spinning and weaving machinery has been adapted to woolen manufacture, an occurrence that soon followed their application to cotton manufacture. England, long a wool exporter, now uses over four times as much as she grows, and leads other countries in the excellence of her wool cloth. The towns of Bradford, Leeds, and Huddersfield in Yorkshire, just across a low mountain range from Lancashire, are known wherever fine woolen cloths are bought and sold. The same resources of coal and iron that served the cotton industry have served other industries, and these Yorkshire woolen districts also manufacture some cotton cloth and a wide variety of metal manufactures, for they are also near to iron and to the eastern harbors.

Britain has been unable to secure such leadership in the world's supply of woolens as has been the case with cottons, nor has the industry been so important. It employs less than half the number of workers employed in the cotton industry. There is considerable equality in the amount of woolen goods produced in Britain, the United States, Germany, Italy, and France, while the rest of the world produces lesser but increasing amounts. Japan, Chile, Argentina, Turkey, Uruguay, Brazil, and Mexico have all made a start, but it should be remembered that Britain produces and exports the finest grades of woolen cloths. The explanation of this greater equality in wool than in cotton manufacture is to be found in the fact that wool manufacturing was a worldwide domestic industry. The Industrial Revolution found wool an established industry and merely transformed it. Wherever men made flour they made wool cloth, and the adaptation of primitive water powers to the hand loom was a small change, much smaller than learning how to use a new fiber such as cotton. Cotton manufacturing was thus almost a new business, resulting from practically the rediscovery of cotton when Whitney's cotton gin made its production cheap. This came after the textile machines were established in England. That country, being in much the best position to manufacture textiles in factories, seized the new raw material and built up a world's trade in cotton, while wool, an industry as old as history, was still being made upon hand looms in millions of farmhouses and in every textile village of Europe and America. With the tenacity which comes of an early start and the hereditary knowledge that lingers in families, wool manufacture has continued in the cooler parts of Europe and America where there is a population dense enough to develop any extensive manufacture. Upon the continent there is really but one wool district, extending from Vienna to the North Sea and the English Channel, including Paris and Berlin. This takes in the valleys of the upper Danube, the Elbe, the Rhine, the Po, the Seine, and includes the densely peopled manufacturing region of Czechoslovakia, Austria, western Germany, Switzerland, northern Italy, northeastern France, Holland and Belgium. Before World War II this continental wool industry was newest and most progressive in Germany, which led

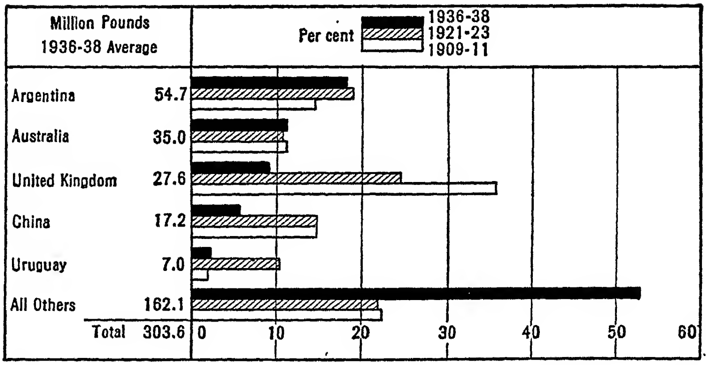
other nations in her deliberate and skillful promotion of industry. Silesia, Saxony and Westphalia, three German coal districts, have been important wool centers.

Wool Manufacture in the United States. In the United States we see the effects of the colonial importance of the woolen industry, for its manufacture is the most widely scattered of all the textile industries. Small mills, comparable to the rural grist mill and driven by small water-wheels on insignificant streams, were established in the last half of the eighteenth and the first half of the nineteenth century over almost all the settled country, and small factories are to be found today in almost every state of the Union, although in many of them the output is insignificant. The large-scale manufacture of modern type, with big factories, is concentrated east of the Alleghenies, north of Maryland, in an almost continuous belt reaching from Wilmington, Del., and southeastern Pennsylvania, through northern New Jersey, southeastern New York, and lower New England into southern Maine. Most of these factories have arisen since 1865. In this concentration of the wool industry, we see another example of the dependence of textile manufacture upon dense population. The valuable wool of Texas, Wyoming, Ohio, and distant foreign countries is carried thousands of miles to the place where abundant labor exists to manufacture it.

Philadelphia is the greatest single woolen-manufacturing center in the United States, but almost every city of importance in this eastern belt has woolen mills. In the New England towns they are particularly common, especially in Massachusetts, which state leads all other states by producing about one-third of the total output. The two states of Massachusetts and Rhode Island manufacture nearly half the woolen goods in the United States. In Rhode Island, which is little more than a collection of manufacturing cities, the woolen industry has great concentration, since that tiny state produces more than the whole United States south and west of Pennsylvania.

With the increase of population and capital woolen mills are now beginning to be built west of the Alleghenies. Ohio, the leading western state, with a growing woolen industry in Cleveland, ranked tenth in 1939, but her production was 6% of the national output. The eastern mill cities, such as Philadelphia, Providence, Woonsocket, Lawrence, and Boston, seem likely to retain their importance for many years to come.

There has been rapid increase in the woolen industry in the United States since the Civil War, when very heavy protective duties were levied upon its import. In the year 1939 American woolen manufactures were worth nearly $736,000,000, but the raw materials, supplies, and containers cost almost two-thirds of that sum. From 1932-1938, about 291 million pounds of wool were required by American mills annually; we imported annually for that same period 58% of the wool we used (170 million pounds). One hundred million pounds of wool are also re-used in making shoddy. The declining importance of wool is indicated by the fact that the woolen mills recently used in one year 9.3 million pounds of cotton and 10.6 million pounds of rayon to mix with the wool. Since the passage of the Wool



United States imports of raw silk, three-year averages (Uruguay, 1937-38 only). The great decline in the United Kingdom marks a decline in Great Britain's entrepôt, or re-export trade. China's figure for the last period reflects the Japanese blockade.

Laboratory Act, the woolen garments have labels giving information about the wool content.

Carpets and Hats. Wool is important in carpet manufacture, but only inferior carpets are made of pure wool. The better ones, such as Wilton, Axminster, and even Brussels have a strong web backing of linen or hemp into which the wool is woven. Philadelphia has long been noted as the great carpet-manufacturing center of the United States, and although the carpet industry there is steadily growing, the increase of carpet mills in some northeastern cities has caused Philadelphia's share of carpet manufacture to decline from nearly a half to about one-quarter. The United States imports all its carpet wool, which constitutes about two-thirds of all wool imports. In normal times domestic sources supply most apparel wools. There is no duty on carpet wool because none is grown in the United States.

Turkish and Persian rugs, the best carpets in the world, come from the oases and villages of the remote interior of Asia. They are the product of pasture and flocks highly condensed by the slow laborious hand labor of a domestic manufacture which, it should be noted, is turning out a better and more highly prized product than the western factories with their mechanically perfect goods. These valuable products are sometimes borne by caravan (now often by truck) to the larger cities or to the seacoast, where Turkish merchants or the rug buyers from Europe or America bargain for them. Before 1915 Constantinople was the center of this trade, but now it has been rather widely scattered among various eastern cities.

Hats were formerly classed with wool manufactures even though they are made by felting rather than weaving, the usual materials being wool or the hair of fur-bearing animals, especially rabbits. The fur of the beaver is used for the finer "top" hats. The coats of domesticated hares and rabbits of north France and Belgium were formerly the mainstay of the American hat industry. By 1923 Australia and New Zealand were furnishing well over half of the imported skins and fur. This branch of

the American woolen industry amounts to $100,000,000 a year, of which nearly two-thirds is paid for the furs. Hat manufacturing is chiefly centered in the district between Danbury, Conn., and Philadelphia, with New York, Connecticut, New Jersey, and Pennsylvania producing most of the output.

finest cloths and are chiefly the product of merino sheep. Our supply of these cloths originates almost entirely in Argentina, New Zealand, and the states west of the Mississippi River. The grade called "Worsted" wool, coarser than "Woolen" wool, is grown in districts east of the Mississippi River and imported from Australia, Argentina, Uruguay, and South Africa. London has long been the greatest wool market in the world, and even in 1940 considerable quantities of wool were forwarded to the United States. A third grade, "Carpet" wool, consists of the coarse, harsh wools produced in countries where pastures are poor, and the flocks therefore ill-cared for. Argentina (arid Patagonia) leads, but China, the Gateway to Mongolia, was long the chief source and doubtless will be again after her ports are reopened, in the supply of this grade. Other sources of important supply are

TABLE 43

UNITED STATES WOOL IMPORTS

	Woolen		*Worsted*		*Carpet*	
	Million pounds 1923	*Million pounds 1940*	*Million pounds 1923*	*Million pounds 1940*	*Million pounds 1923*	*Million pounds 1940*
England	11.9	3.3	48.4	1.6	22.9	8.8
Argentina	6.1	15.9	55.3	6.2	9.1	45.5
Australia	3.8	1.1	49.4	28.2	...	...
Uruguay	3.0	1.4	35.5	15.3	...	0.6
British South Africa	...	1.6	14.1	6.8	...	1.2
New Zealand	...	7.0	12.9	4.1	...	9.2
China	...	0.3	...	...	51.4	2.3
Scotland	...	...	...	...	10.5	...

Source: Commerce and Navigation of the United States (1923–40).

Transportation and Import of Wool. The high value of wool causes the cost of transportation to be but a small percentage of the total cost of the wool bale at the mill, so that the place of production has but little influence upon the place of manufacture. This is even more conspicuous in the case of wool than with the less valuable cotton. Our chief wool-producing districts are west of the Mississippi River. The diverse requirements of different mills give us very scattered sources for our imports. The best wools—known as "clothing" or woolen type—are used for making the

New Zealand, China, British South Africa, and Scotland, where the hardy highland sheep, braving the storms of his mountain heather pasture, produces a coarse wool little used in English manufacture, but well suited to certain American carpet factories. An instance of the tendency of wool to make long journeys is shown by Australia, the largest wool producer and grower of the best wool in the world. It exports 82% of the wool it grows, sends it halfway round the world to west Europe and the United States, and then buys back, chiefly from Britain, some of the woolen manufactures. However, Australia's 1928 woolen piece goods imports of 1,464,000 pounds sterling declined to 282,000 pounds sterling in 1936. Her own production of woolen piece goods in 1936 was 12,283,000 pounds sterling. (See also the chapter on steel.)

The Limitation of Raw Materials. Wool, like leather, is scarce and becoming more so with small prospect of adequate increase of supply to meet increasing population. Wool is largely a by-product of the meat industry, and the conditions of the wool manufacturing cannot affect the raw material supply so directly as cotton manufacturing can affect its raw material, since cotton is a product grown for its own sake. A 25% increase in the price of wool, say from 24 to 30 cents per pound, amounts to 30 or 40 cents increase in income per sheep per year—a factor of small importance. A similar increase in cotton, from 12 to 15 cents per pound, changes the entire basis of the business and causes great and prompt increase of output, for the cotton grown to meet the new demand would be on the market in a year or even less,[17] while the wool resulting from a desire to increase the output would have to await the maturity of animals yet unborn. The cotton and wool industries have, therefore, fared very differently in the past 25 years. While cotton production and manufacture have been going up by leaps and bounds, the production of raw wool throughout the world has increased but little, and has at times remained stationary or even declined. The world's production of wool has remained about 3.8 billion pounds annually, 1931-38. As a result, cotton and other natural and artificial fibers have been substituted for wool in many of its uses. If the process of substituting other fibers for wool does not continue, we are likely to have much higher prices for wool because of the large amount of land needed to produce it. But watch the synthesizers! They may hand us artificial wool any day, made from tar or potatoes or garbage.

The industrial awakening of China and Japan, and their adoption of Western ideas and methods, will increase rather than diminish the world scarcity of wool.[18] They had worked out very efficient and satisfactory clothes of cotton and silk but have foolishly begun to adopt Western clothing.[19] European

[17] Therefore the cotton-grower meets wild fluctuations of price and prosperity, unless government helps him out, as in the United States.

[18] An eminent British authority estimated the world fiber production at or a little below 30 billion pounds, of which cotton was 62½%; clean wool, 7.7%; jute, 11.7%; hemp, 6.3%; flax, 5.3%; rayon, 6%; silk, 0.3%. (From Textile Division in U. S. Dept. of Com., 1944.)

[19] "Foreign style garments are becoming increasingly popular (in Japan), and the vogue for wool has become so infectious that even the traditional kimono is being made up in wool of gossamer-like texture."—National Bank of Commerce, *Commerce Monthly,* March, 1924.

styles demand wool, and Japan, with practically no wool supply, increased her import of wool and yarns from about 23 million pounds in 1914 to 212 million pounds in 1939. What will the Chinese do if they really mechanize and westernize (in economics)? China exported only one-fourth her annual production of 110 million pounds 1931-38, although the native styles of clothing can be supplied by cotton and silk, chiefly cotton. The adoption of Western styles of clothing by modernized China has called for wool and will continue to do so.

The woolen industry is one peculiarly subject to the influences of style. As Dame Fashion causes skirts to lengthen and shorten, joy and sorrow alternately fly back and forth between the camps of the cloth manufacturer and the hosiery manufacturer. A large part of the woolen cloth is used for external clothing, and when the styles in women's dresses suddenly require 3 or 4 yards where they previously required 12, it makes dull business and gloom in wool-manufacturing towns of the northern hemisphere and in the fine wool-growing districts of the southern hemisphere.

5. *Other Wools and Hairs*

The other animal hair fibers used for fabric seem destined to continue in very secondary place—as the alpaca, vicuña, and llama wool with their resulting fabrics, the camel's hair with its fabric, the Cashmere goat's hair with its fabric. Certain coarse felts are made of cow's hair, but the uses for such fabric are limited, and most of the hair that might be obtained is unused.

Mohair is the fleece of the Angora goat, of which four or five are raised as household pets by many a family in Asia Minor. Its high silky luster has made it popular in the manufacture of plush for upholstery, and in many woven fabrics, such as are used for men's summer suits. The value of the mohair industry in Turkey attracted other pastoral nations, and in 1848 the first Angora goats were brought to the United States. The Edwards Plateau of Texas is an ideal goat country, offering the necessary features of a rugged country, mild winters, dry atmosphere, good browse for pasturage, and low land values. The United States produced 21.8 million pounds of mohair in 1941, 18.8 million pounds, or 86%, coming from Texas. During 1936-38, the United States produced 45% of the world's total (36.6 million pounds), Turkey, produced 35.5%, the Union of South Africa and Basutoland 17%.

All of the minor animal substitutes for wool are insignificant in comparison to the great substitutes, cotton and rayon.

In the last quarter of the nineteenth century, hair cloth was in vogue especially for furniture covering. It is a smooth, black, shiny, clean, cool fabric made from the manes and tails of horses. Hair cloth still has many uses, but this hair is now chiefly used for mattresses, for which purpose it is curled. The bristly hair of the pig has been used for many kinds of brushes, and the bristles themselves have come in large quantities from China where the patience of the low wage worker prepares them for market. The makers of the synthetic nylon are now spending thousands of dollars weekly to ridicule and drive out the hog bristle. The softer hairs of the

badger's coat make shaving brushes, and the yet softer "camel's hair" supplies us with fine paint brushes. (Actually it is squirrel's hair which for some strange reason is called "camel's hair" in commerce. The softest and strongest of all soft hairs is Kolinsky, the red sable.)

6. *Silk*

How Silk Is Procured. Hundreds of species of insects spin cocoons in which to pass the chrysalis period of their lives. One of these insects, a moth, most commonly spoken of as the silkworm, makes a particularly fine cocoon, the fiber of which we call silk. The process of spinning is very similar to that by which the spider makes its web, except that the silkworm winds its thread around and around itself, and the thread may be unwound without breaking if the worm is killed—as it may be by roasting—before it cuts the thread by eating a hole in the end of the cocoon to emerge as an adult moth. The fibers are so fine that five are required for fine thread, and ordinary silk thread has ten to twenty fibers. The cocoons are soaked to loosen the fiber, the ends of several strands are placed together and the several cocoons then are unwound to make the thread of raw silk. This laborious process adds greatly to the cost of silk, which is ever the product of much labor.

The favorite and chief food of the commercial silkworm is the leaf of the white mulberry, a tree which will grow in the tropics and in the temperate zones as far as the grape extends, so that natural conditions for silk production are good in much of Europe, a large part of the United States, as well as some large part of every other continent. The successful prosecution of the industry, however, requires a second crop of leaves upon the tree and this requires a temperature of 54.5° F. for at least three months. Owing to the great amount of labor involved, the distribution of the production of silk, however, depends not upon climatic conditions alone, but upon the labor supply, which must be both abundant and highly skilled.

The Raising of Silk Worms. The eggs of the adult moth are carefully collected; and upon hatching, the voracious young worms are kept in a house upon trays which must be kept clean through the weeks during which the greedy worm devours his daily portion of fresh mulberry leaves, brought in mostly by women and children. When young, the worms are fed very finely chopped tender leaves five or six times a day and two or three times at night. The worm can endure less cold than the mulberry tree, so the worms are kept in heated rooms in Europe and also in parts of China and Japan. Humidity and temperature must be closely watched or epidemics may carry the worms to a speedy death. When the worms have reached adult size, they crawl into bundles of straw to spin the cocoons (in 24-48 hours) which the women pick out by hand. Throughout the whole life history of this insect and in the preparation of the fiber, the labor must not only be cheap, but careful, patient, watchful, and deft of hand. It thus becomes an industry that thrives where the labor of women and children is cheap, as in the densely peopled parts of the Old World. It is easy to understand why the various attempts at silk growing in the United States have failed, despite the many baskets of sample cocoons that have been

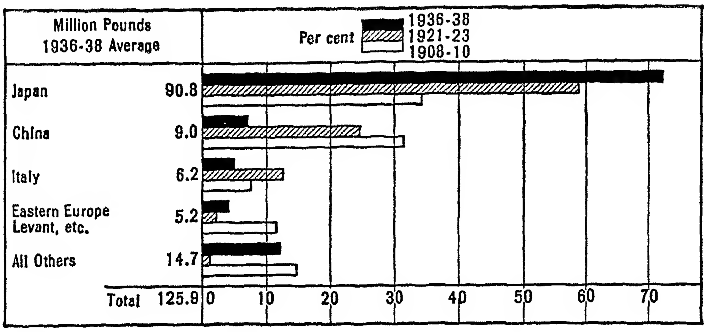
produced, and despite the great anticipations that accompanied the planting of thousands of mulberry trees which have thriven,[20] produced good leaves and but little silk.

Oriental Silk Production. The production of silk responds to this labor factor so surely that the industry is readjusting itself in accordance with it. The forcible opening up of China, the modernizing of Japan, and the resulting development of transport facilities have exposed the silk growers of the world to Oriental competition. France and Italy have been growing silk for centuries, the governments have aided the silk industry all they could, but their silk growers have felt Oriental competition, and the output has declined; the European crop in 1906-07 averaging 12.8 million pounds, that of 1922-23, 8.2 million pounds, and that of France, Italy, Greece, Turkey, and Bulgaria 7.7 million pounds in 1936-38. During this period, the Oriental exports increased from 28 million to 55 million pounds in 1922-23, and 94.4 million pounds in 1936-38 exclusive of China. Perhaps the greatest silk-producing region is China, although we have no accurate statistics of the amount used by the Chinese themselves. It is a household industry of the peasants centered between 30° and 35° north latitude. This corresponds roughly to the Yangtze Valley, a region whose silk output, particularly from Chekiang and Kiangsu, has made its metropolis, Shanghai, one of the world's great silk markets. Canton in south China has also a considerable silk center with many silk filatures employing 500 persons each. In Yunnan and Szechwan, schools of sericulture have spread the knowledge of silk production so that the people have a substitute crop for the forbidden opium, which has been so important there, and have been able to maintain the silk culture away from the Japanese-held coastal areas. In various parts of the country, several wild moths produce a marketable kind of silk, so that one-fifth of the Chinese silk is known as wild silk. With the silk industry more scientifically and systematically organized, there is almost no limit to the amount of raw silk China could produce.

Japanese Silk Production. The greatest silk-exporting country is Japan, and this people, being more forward than the Chinese in the use of scientific devices, adopted filatures, or machines for unwinding the cocoons and preparing the raw silk of commerce. The Japanese have applied the science of bacteriology skillfully to prevent silk worm epidemics. The Japanese silk export has increased more rapidly, therefore, than the Chinese export, with the result that the Chinese are now adopting the new method of preparing it. Japan represented 77% of world silk exports before World War II, China less than 9%.

Silk is particularly suited to the conditions that prevail in Japan. The monsoon rains of summer give the moisture needed to make the mulberry trees yield abundant growth of leaves. The small proportion (less than a sixth) of the land that can be cultivated in standard

[20] In Mineral Wells, Tex., the first large commercial silk crop has been harvested. A new American invention unreels more silk in seven days than can be done in 100 days by hand. The unwinding has been one tedious task which has concentrated silk preparation in areas of cheap skilled hand labor. The Texas outfit expects to produce 40,000 pounds of silk its second year. Cross your fingers. This is United States silk boom No. 49!



Production of raw silk, three-year averages by per cent, last period by quantity. The steady advance of Japan represents low wages, need of foreign credit and very scientific promotion of silk production. The decline of China in the middle period reflects her lack of system, the sharp decline at the last represents the blockade. Apparently Italy could not meet the competition of extremely low Japanese wage.

style leaves abundant room on the hillside for the mulberry trees, and the overcrowded population furnishes the labor. It is natural, therefore, that this opportunity should, in a land of scanty raw materials, be eagerly seized upon, as shown by a 50% increase in the export of raw silk within 10 years, 1912-1922. In 1929, 77 million pounds were exported. In 1940 the export was only 38 million pounds; since production was usually close to 100 million pounds the export decline may be explained by greater consumption. Silk has been the most important single item in providing Japan with foreign exchange. In the early 1920's, raw silk represented 40% of Japanese exports, 21% from 1935-39. In 1939, the United States took 80%. Since in the same year more than one-third of Japanese farm households raised cocoons, the disappearance of the United States market has been a national as well as individual problem.

Rayon has of course cut into the silk market as well as the cotton market, and some better artificial silk may send real silk to the museum. This will indeed be tragedy for Japan, for that crowded poor country needs silk as never before and could produce it in much larger quantity.

Early attempts at introducing silk culture in India have led to a considerable production for local use, but the export has never been important nor does it promise to be, either in India or in any of the minor producing regions of southern Asia and Asia Minor (especially Syria). A little silk is produced for home use, but the labor conditions are not equal to those of the Far East.

The Commerce in Silk and Its Production in Europe. For centuries silk was the mainstay of commerce between the Far East and the Mediterranean world, and the Chinese jealously prevented the export of silk moth's eggs. However, according to legend, an enterprising traveler finally broke the embargo and carried some away in a hollow bamboo walking stick, so that in the sixth century A.D., the growth of silkworms became common in Greece, southern Italy, and Spain. In all of these districts the amount produced is negli-

gible, because of the Mediterranean climate and the small amount of arable land which force the use of crops with a richer harvest than mulberry leaves. But silk is locally important in northern Italy where, upon the level and irrigated plains of the Po, more than four-fifths of the European crop is produced. Here a traveler may never see an open field for miles because of the rows of mulberry trees, bare in early summer because leaves have been stripped for the silkworms during their seven weeks of rapid growth in the springtime. The intensity of Italian agriculture is attested by the fact that while wheat and other grains are grown between these rows of mulberry trees, the trees themselves are so trimmed that each tree holds out its two branches as arms to its neighbors, and upon these outstretched arms grape vines are often trained. Thus three crops are obtained from the same land and irrigation water.

During the medieval prosperity of the Italian city republics, Bologna, Lucca, and other cities of north Italy were famed for their silk manufactures, and in 1515, when Francis the First of France conquered Milan, he introduced Italian silk workers into France. They established the silk-manufacturing industry at Lyons and the cultivation of silk in the valley of the Rhone. For a long time it was more important here than in Italy, but the greater density of Italian population in the Po Valley in recent decades has given that district the leadership in European silk production.

Pasteur and the Silkworm Disease. Silkworm production affords a fine example of the dependence of industry upon science. In 1853 a silkworm disease appeared in the Rhone Valley and threatened the silk industry of the world, as the phylloxera later did the grape industry. The French scientist, Pasteur, at the order of the French Government, investigated the silkworm disease and found that, by the use of the microscope, he could detect the healthy insects. Only the healthy were permitted to lay eggs, and thus a sound generation of worms was produced. The French silk industry, which had declined 90% between 1853 and 1876, again steadily increased for thirty years. At present France raises less than 1% of the world's silk, and depends upon Italy and the Orient for raw silk.

Comparison of Transportation and Labor Factors. Since silk has high value per unit of weight, labor is the determining factor in locating the business. The peasant who produces $6.00 worth of wheat must deal with the problem of paying freight on 200 pounds of freight, more or less. If he produces $6.00 worth of raw silk, he has to pay freight on only 4 pounds. A freight rate of 3 cents per pound is 2% on the silk, and the same freight is 100% on wheat valuation. The freight is, therefore, a somewhat negligible factor in sending silk half-way around the world from the place with the most desirable conditions for the production of raw silk to the place with the most desirable conditions for its manufacture and sale. It is easy to understand why the United States, the country with the greatest silk manufacture before 1942 did not produce a bale of the raw material.

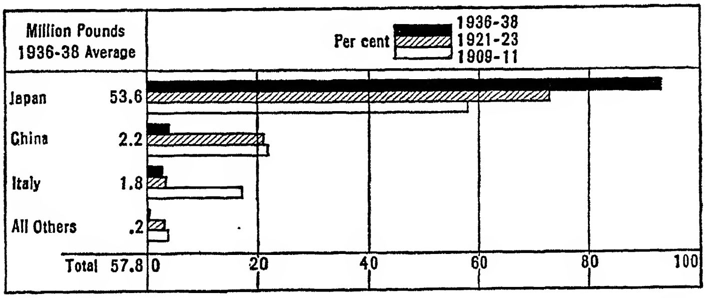
Silk Manufacture in Foreign Countries. Silk fabrics have long been more largely used in China and Japan than in any other part of the world. Some of the hand-made fabrics are of most excel-

lent quality, but, owing to the relative superiority of Chinese and Japanese in the production of raw silk, and to the influence of Western tariffs, the Oriental exports of fabrics have been limited to small amounts, and they are chiefly the inferior or thin goods made by the newly introduced Western machinery. During the nineteenth century, France has been the great leader among the nations of the world in the manufacture of silk, the center of the industry being in Lyons, in the raw silk-producing section. The Jacquard loom, which was invented there early in the nineteenth century, produced figured brocades of great beauty and excellence, and French brocades became famous wherever ladies dressed in Parisian style. Toward the end of the nineteenth century, the ease of sewing made possible by sewing machines and the rapid communication established by mail and telegraph, caused fashion in ladies' dressing to change so rapidly that a valuable French brocade which would last for years, would long outlast the style. Hence, the preference was for less expensive, less durable, but equally beautiful fabrics. These the Germans and the Swiss, with their policy of pleasing their foreign customers, promptly supplied. The prosperity of Lyons waned, and it took years of depression to convince the manufacturers of that city that their silks were too good for the market. Lyons again became the leading silk center of Europe, however, with an output valued at $126,000,000 in 1921, and her looms were famous for producing new and exquisite weaves to suit the ever-changing whims of fashion. However, the total output of France in 1934 was $74,750,000. Lyons has stuck to real silk more or less in spite of the rayon invention. It produces mostly real silk fabrics and to a little extent mixed fabrics. Roanne, north of Lyons, has become important as a center for staple fiber fabrics and products.

The Swiss silk manufacturers are scattered through many towns, but Zurich is the chief center of the manufacture of cloth. The German silk industry increased rapidly in the 1930's and availed itself of the teachings of science. Important centers were Krefeld and Wuppertal. At a school of silk culture at Oederan in Saxony, the first of its kind (1939), children were to be taught the silk culture. This is an industry that Germany can continue.

British Silk Industry. The silk industry in Britain is a small reputable one but relatively unimportant for a nation so great in textile manufacture. Great Britain's lead in cotton was duplicated by the similar early success of France in silk manufacture, which enabled the mills of that country to compete with those of Britain even in their own market. Of late years there has been some manufacture of processed goods such as pongee, which is imported from China and Japan then printed and exported as liberty silk. The best silks used in Great Britain are imported, and the total number of silk employees is about half of that in the United States.

Silk Manufacture in the United States. The production of fabrics of silk and the substitutes has risen rapidly in the United States. The value was $42 million in 1870, $103 million in 1909, and in 1939 silk and rayon together were $442 million. Most significant of all is the fact that silk was $98 million, and rayon was $344 million.



The United States import of raw silk, three periods by per cent, last period by pounds. Japan certainly did make war on her best customer.

Silk manufacture is comparatively light work, and the percentage of women operatives in the silk mills is higher than in any other branch of textiles. This predominance of women gives the silk throwing mills a tendency to be what is sometimes called a "parasitic industry"; that is, it is located because of the presence of other industries which employ large numbers of men, so that the wives and daughters of the workmen make a labor supply which encourages the starting of silk mills. Paterson, N. J., an important place for the manufacture of various classes of iron goods, which employ large numbers of men, has for this reason long been the most important silk-manufacturing town in the United States, having produced over a quarter of the total silk product in 1890, about a fifth in 1921, and about one-eighth in 1939. This relation of the silk to heavy industries is well shown in Pennsylvania, where the silk mills are located chiefly in and near the coal-mining towns, especially Scranton and Wilkes-Barre, and the cement-manufacturing towns of Allentown and Easton in the Lehigh Valley, and in the agricultural implement-manufacturing town of York, and more recently in the coal and iron region of western Pennsylvania. Silk manufacture has also made some headway in southern New England and in New York, but Pennsylvania and New Jersey each manufacture about one-third of the total. Thus it is seen that the industry is thoroughly concentrated in a rather limited industrial area.

Artificial Silk and Other Synthetic Substitutes

The silkworm's job is in danger. Man has entered into active competition with the silkworm, and although the worm has the advantage of several million generations of previous practice in the art of silk making, man is rapidly catching up. Artificial silk is the most recent addition to the world's important textile fibers. The silkworm makes silk by drawing the fine threads from a jelly-like mass of cellulose (called sericin) in its head. This material is made from the cells in the worm's vegetable food, as changed by the chemistry of its body. Man has copied the worm's process. By the chemistry of the laboratory, wood-pulp and cotton linters may be converted into a jelly much like that from which the caterpillar makes its silk. By air pressure this cellulose is driven

through very small apertures in glass. Each aperture makes filaments so small that, as with silk, it sometimes takes 150 of them reeled together to make a thread. The rayon industry since 1930 has developed a primary raw-spinning staple fiber by cutting untwisted lengths to correspond to the staple of spun silk, raw cotton, and wool, in which form it can be spun into yarn on the machinery of the established branches of textile manufacture. There are four different processes for making rayon, the products being viscose, cellulose acetate, cuprammonium, and nitrocellulose rayon. Viscose is the cheapest to produce and the most important, constituting about 83% of the world production in 1938.

Count Chardonnet, a Frenchman, after many years of investigation obtained the first artificial silk fiber in 1884. For many years it was considered nothing more than an interesting curiosity. By further experiment the early difficulties of weaving and dyeing were overcome, and artificial silk was finally recognized as a satisfactory raw material and in a class with the other vegetable and animal fibers. There is now direct competition between natural silk and the synthetic product. The high luster, versatility, and adaptability for blending and design effects, and its lower price have enabled it also to fill a place of its own equal to the other textile fibers. Its greatest use has been in the weaving industry, in combination with wool, cotton, or silk, or as pure rayon. It is significant in the knit goods industry as hosiery, scarfs, sweaters, ties, and similar products. This successful commercial use of purely chemical fibers represents a triumph for the man of the laboratory, of which we should have many more in the future.

The world production of rayon has had a striking increase from 4.4 million pounds in 1902 to 80 million pounds in 1922, to 991.6 million pounds in 1938. First made in France, it has become a great industry in Germany, Italy, Great Britain, Japan, and the United States. As late as 1913 our production of the new material amounted to only 1½ million pounds, but urged on by the high price of natural silk, its manufacture increased to over 35 million pounds in 1923 and 257.6 million pounds in 1938. The industry is concentrated in the South where twelve plants account for almost 70% of the installed capacity of the industry. The two foremost producing states are Tennessee and Virginia; others are Maryland, West Virginia, North Carolina, and Georgia. The East Central District and Middle Atlantic account for 26% (Pennsylvania ranks third in the United States as a rayon producer). New England accounts for about 5% of our total plant capacity. The total world production of rayon is nine times that of the silkworm product, which amounted to 110.6 million pounds in 1938.

The possibilities of fiber silk are by no means all discovered, and chemists are still improving it. It should be noted that this fiber is made chiefly from cotton or wood pulp, both abundant raw materials. The United States, with its wealth of materials and mechanical advantages, can and is developing not only fiber silk, but other new materials from synthetic sources. Man is no longer dependent only on what he can pick up in the plant or animal kingdoms, but

is learning to alter their materials to suit his needs.

Nylon. Before 1930 a chemical research program began to find out why and how small molecules formed the giant ones found in cotton, silk, resin, and rubber. In 1938 a new synthetic fiber was announced which surpassed any known textile fiber in strength and elasticity.

The first step in the manufacture of nylon is the conversion of certain gases and coal-tar fractions. The elements entering into these compounds are carbon (from coal), hydrogen (from water), nitrogen and oxygen (from air), therefore the popular characterization of nylon as a product of coal, air, and water.

Nylon is used for hosiery, underwear, dress goods, parachutes (canopy cloth, shroud lines, harness webbing, and belting), tire fabrics, and ropes for towing gliders. Nylon shoe laces have been adopted for jungle footgear because of its resistance to moisture and mildew.

Nylon grew from a chemical curiosity in a few years to a full-scale industry employing more than 3,500 directly and many more indirectly, by providing a new fiber for textile mills which might otherwise have been shut down for shortage of raw materials.

8. The Plant Stalk Fibers

Machinery has revolutionized the textile industry by giving it new ways to produce its old results. It has revolutionized it also by giving the new seed fiber, cotton, in place of the stalk fiber, linen, and it may cause further revolution by enabling us to use other cheap stalk fibers. Several thousand plants contain fibers of good quality for textile use if they could be secured in cheap abundance, and several dozen such fibers are actually in extensive use in various parts of the world. There is no guarantee of the continuance of cotton's leadership in plant fibers, as some stalk fiber cheapened by machinery may some day supplant it.

Flax and Its Preparation. Flax is now, as in the past, the most important plant stalk fiber entering into our clothing. This plant, a member of the nettle family, has been yielding linen since the pre-historic lake dwellers inhabited the Swiss lakes, and the mummies, bound up in linen cloth, were placed in the Egyptian tombs four or five thousand years ago. Before the invention of the cotton gin, the common stinging nettle was much used in Europe as a substitute for flax. In 1790 when cotton was less used in manufacture than China grass or ramie is now, flax was the most important of all vegetable fibers. It was grown on almost every European and American farm, and in many an old American home the implements for the preparation of flax are still to be found. The introduction of cheap cotton caused the disappearance of flax from gardens at about the time that the spinning wheel and the hand loom disappeared from homes.

The plant is somewhat branching, but otherwise resembles the small cereals in appearance and method of cultivation. For fiber it must be pulled, piled up to dry, and the seed removed with an iron comb; then the straw is "retted"—a process of partial decay to make easy the separation of fiber. In some places it is retted in bunches, spread upon the ground of moist meadows; in others, as

in Ireland, it is immersed in water. In Belgium, where a small flax industry still survives, the water of the river Lys is of peculiar fitness in retting flax, and in it the straw is immersed for a few days' time, then dried, subjected to two more wettings, during which it decomposes and is ready for the "breaking." This is accomplished by running the straw through rollers, after which the separation of the fiber is accomplished, sometimes by hand, sometimes by running the straw through a machine with dull knives. Fibers thus obtained are from 8 to 50 inches in length, strong and durable, but since the coming of cotton, the labor of getting it out of the stalk has made its production impracticable wherever wages are high and import of commercial products easy.

Flax is unquestionably superior to cotton for many uses, but from the standpoint of competition on the point of cost, it rests under yet other handicaps. Although flax grows in a far wider range of climate than cotton, it is much more easily injured by drought or wet weather, and the difficulty of preparing it gives lack of uniformity, a serious handicap to the manufacturer. The fiber is harder than cotton to manufacture, requiring more power and more labor. Machinery has increased the linen spinner's efficiency only about one-half as much as it has the cotton spinner's efficiency.

Distribution of Flax. The flax plant has an exceedingly wide range, having produced good fiber all over the eastern United States and on the other side of the Atlantic, from Algeria, Italy, and Yugoslavia to Scotland, Sweden, and Russia. The cultivation of the flax plant for its fiber, like silk culture, shows a decided response to labor conditions—density of population. In sparsely peopled countries like Dakota and Argentina the laborious hand processes of harvesting and preparing flax are impossible, but they fit well into the scanty opportunities of the cold Baltic shores, or of north Russia, where the Archangel district produces most of the flax fiber. The chaos in Russia following World War I interfered greatly with flax production, the export falling from 600,000 tons in 1914 to 20,000 tons in 1922, but rising by 1934 to 550,000 tons. Before World War II considerable flax was grown in Poland and in what used to be Lithuania, Latvia, and Esthonia. Belgium, France, Rumania, Yugoslavia, and Czechoslovakia are also flax growers.

The Linen Industry. The manufacture of flax into linen is particularly important in the United Kingdom. The north of Ireland (especially near Belfast) and the south of Scotland, which a century ago grew flax and manufactured it in hand looms, now are the centers of the world's finest factory-operated linen manufactures. This location of the linen industry is an excellent illustration of the influence of an early start. Next to agriculture, the manufacture of linen is the most important industry in Northern Ireland, employing directly or indirectly one-fifth of the gainfully occupied population. In 1935 there were 875,000 spindles, 28,000 looms, and the output of linen piece goods was over $6 million. Skill and tradition have been handed down from Huguenots who came in the seventeenth century. Before World War II, Belfast got most of its flax fiber from Belgium, from the small Baltic countries, and from Russia.

Linen from the Belfast looms is exported all over the world where fine fabrics are appreciated, the United States taking the largest share.

In Germany the linen manufactures of Westphalia were famed, as were also those of Bohemia and Belgium, while certain grades of linen are made in the textile region of northern France. One of the surprises of the period following World War I was a greatly increased manufacture of linen in Japan, which recently grew more fiber flax than Ireland, although not enough for home needs. Japan has even sold her linen in London, but not in real competition with the looms of Belfast.

Linen manufacture has been exotic in the United States, and was of small amount, being only a fraction of the import, which amounted to about $25,000,000 in 1923. In 1939, however, imports of thread, flax yarn, and fabrics of flax cloth totaled only $1.1 million—one-sixth of the linen manufacture in the United States, $6.3 million dollars. Here we see some results of the war between the laboratory (rayon, etc.) and the field.

Seed Flax. Flax fiber is produced chiefly in Europe, but seed flax is grown in several of the important wheat region, as Argentina (one-half of the world's crop), central Russia, the Spring Wheat Belt in the United States and Canada, and northern India.[21] In all these districts, with a total crop of 112 million bushels in 1923-24 and 135 million bushels in 1939, flax is, from the agricultural standpoint, not a fiber but a cereal planted like wheat, harvested with the most improved reaping machinery, threshed by steam, and handled in every respect like wheat with no thought of saving the fiber that is in the straw. Of the total American crop of 30.9 million bushels in 1940, Minnesota produced 17 million, North Dakota 3.7 million, Iowa 2.6 million, and South Dakota 2 million bushels. The 1943 crop of the United States was 52 million bushels.

The seed, upon being crushed, yields linseed oil, much used as a raw material for the paint and varnish factories of Philadelphia and other eastern American cities. The "oil-cake" that remains is highly valued as food for livestock and is shipped by way of New York, Montreal, Boston, and Philadelphia to feed the herds of dairy cows in Holland, Denmark, Belgium, Ireland, and Great Britain.

A Possible Textile Revolution. The textile industry is constantly hoping for new and better fibers or cheaper processes of using the fibers we now have. Inventors have been striving for three goals, any of which may make a revolution resembling that of the cotton gin. One is a really successful cotton picker that will do away with much of the laborious hand work and enable cotton to be sold at a much lower price than that which is yet expensively picked by human fingers. The second is a machine or process that will enable man to get the fiber from flax or some other plant quickly and cheaply. The third is the development of synthetic fibers which can be woven on the same textile machines as cotton, silk, and linen and replace them in usage. The success of the

[21] The fact that flax can be grown in the winter on the same land that grows the Egyptian cotton crop has caused the Egyptian Government to encourage this industry, which will in a sense be new for Egypt, though in a sense it is very old, for they wrapped their mummies in fine linen when the ancestors of all the rest of us wore we do not know what, nor where, nor how.

cotton-picking machine and the flax decorticator, if both should come into use, will enable mankind to reap the benefit of the great industrial race to the fabric market—a cheapened clothing supply. If plant breeders set themselves to the task, there is good reason to think that varieties of flax can be produced capable of yielding both seed and fiber. The development of rayon and nylon has brought a revolution to the textile industry whose far-reaching results are as yet not fully recognized.

The popular summer fabric called Palm Beach cloth is made of fiber that grows wild on a very common tropic tree called the ceiba. This fact is very suggestive, especially in view of the further fact that apparently nothing has been done either to improve the yielding qualities of the tree or even to adopt the common horticultural practice of propagating the best.

Ramie, one of the best of the Oriental plant fibers, is much used as a substitute for linen. Ramie and China grass are the same thing at two different stages of manufacture, China grass being the name for the rough brown fibers, which are called ramie when bleached out. The fibers are stronger than any other natural fiber, or rayon, and most nylon. The fiber of ramie is long, average staple is 6 to 8 inches, larger than that of wool, which is the longest natural commercial spinning fiber. When woven the cloth is fuzzy in appearance, and when properly dyed it holds colors well. It makes excellent embroidery and bobbin lace.

Ramie thrives best in temperate climates where the danger of frost is at a minimum. It is grown all through central China, and Swatow prepares more ramie for market than any other city. The de-gumming process is very difficult, yet ramie is being spun in Japanese linen mills, and there are in addition some successful ramie mills. In the Orient ramie is in wide use, and it has possibilities of becomng a flax substitute and possibly to some extent a cotton substitute in the western world, since recent innovations in decorticating and processing machines make commercial utilization able to compete with Oriental hand labor.

The successful experimental planting in Florida of 1,000 acres has resulted in planning for 10,000 additional acres. World War II has brought increased attention to ramie for rope.

Hemp. Hemp, the fiber of common cordage, is closely allied to flax, of which it is really but a coarser variety and therefore fitted for coarser uses. It is used in almost every rope factory in the United States and Europe. The fiber is separated from the stalk by processes similar to those used in flax preparation. One-third of the world's commercial hemp comes from the flax districts of south Russia. Italy produces the highest priced hemp fiber, which is imported into Great Britain, Germany and the United States for commercial twine, coarse toweling, and carpet yarns. American hemp for a long time had a declining output due to the competition of cheaper labor in other hemp-growing countries, but especially, through the competition of cheap jute. However, dislocations of production and trade during World War II resulted in emergency planting of 168,000 acres under governmental contract in 1943, and 60,000 acres in 1944 in Kentucky, Illinois, Wisconsin, Minnesota, and Iowa.

Several fibers rendering service similar to that of hemp have, upon their appearance in the world market, been called hemp regardless of their origin. Among these are sunn hemp and Deccan hemp, much used in India. Both are fibers from the inner bark of plants.

Jute. Practically all the world's supply of jute, the cheapest fiber in general use, comes from the Ganges Valley. In northern and eastern Bengal near Calcutta, along the overflowing Ganges, there is the right combination of tropical climate, flooded land, and abundant labor to make a crop of this tropic plant. While adapted to all soils, most of the product is grown on the overflow land near rivers, because the plants easily stand flooding. Like flax, hemp, and many other fibers that are not gummy, it is separated from the stalk by being soaked in water. After the bark is stripped off by hand, the plant tissue is washed away by beating the plant upon the surface of the water in which the laborer stands.

Jute has been long used in India where common gunny sack was first produced by hand looms. In 1835 the manufacture was taken up in Dundee, Scotland. The origin of the industry in that city is an interesting example of the chance location of industries. In the eighteenth century epoch of hand-loom textiles the vicinity of Dundee was famed for good flax which its people made into linen. After the removal of the source of flax supply to Russia, the Dundee weavers began to import and manufacture sunn from India, and with it the other Indian fiber, jute, which bore the same relation to hemp that hemp did to flax. As a result, Dundee established a jute industry in which it had for a long time a monopoly of the entire western world. By way of Liverpool and London, it exported and yet exports large quantities of gunny sacks, the cheapest of all strong fabrics—to America for the shipment of wheat and corn and the covering of cotton bales; to Brazil for coffee and cotton sacks, to Argentina for grain sacks and wool bales; and to Australia for wool bales. During the latter part of the nineteenth century, jute mills were established in other linen-manufacturing centers of the United Kingdom, on the Continent, in Calcutta itself, and also in Boston and Philadelphia. The manufacture of jute products is one of India's two leading manufactures, and Calcutta is still its greatest center. The total exports of finished jute products in 1922 amounted to over $106,000,000, while raw jute brought in $64,000,000 more; in 1939 exports of jute manufactures amounted to $98 million, while raw jute brought $50 million—jute representing almost one-fourth the value of India's total export trade. The jute mills of India employ nearly 300,000 workers.

Jute is used to some extent in the carpet mills of Philadelphia and many other cities. We imported 66,000 tons in 1935, 92,000 tons in 1937, and 35,000 tons in 1938. It averaged 4.6 cents a pound in 1935-39.

Abacá (Manila Hemp). This best of rope materials is not hemp at all, but a coarse fiber sometimes eight to ten feet long, found in the pithy stalk of the abacá, a fruitless member of the banana family. This plant is cultivated not only in the Philippines, but also in a small way in Panama, Costa Rica, Nicaragua,

Guatemala, and Honduras.[22] It thrives best on the slopes of volcanic hills in a moist climate, and it will not do well in water-soaked or very dry soil. Its culture is easy, but a long drought is fatal to the plant. This plant conspires with the climate to keep the Filipino from steady work. Man does not usually like to work regularly, and it is often not necessary in the productive climate in which fortune has placed the Filipino. He can from time to time plant a few suckers of the abacá plant, and in two or three years he can cut them down, split them into strips a couple of inches wide, scrape away the pulp with a sharp knife, and sell the long, white, shiny fiber to traveling Chinese merchants, who gather it up and take it to Manila. They pay sufficient cash to meet the small financial needs of the tropic family for a few days or weeks until pressing need makes it desirable to scrape a little more fiber. Scraping thirteen pounds of good fiber is a day's work for a man.

Attempts at introducing Manila hemp growing into other parts of the world have been slow (save a little of poor quality in the Dutch East Indies), and it has been practically a monopoly of the Philippines, where there is a great abundance of admirable, unused abacá land.[23] The fiber is fourth in value of Philippine exports, and is shipped in large quantities from Manila to London, Liverpool, New York, Philadelphia, and San Francisco. It makes the strongest of rope, which is especially prized in the rigging of ships since it does not weaken or swell in sea water, and when worn out for this use it is ground up to make the exceedingly strong paper known as Manila. It is also much used for the manufacture of twine used in binding up the bundles of wheat in self-binding reapers, for which purpose approximately $20,000,000 a year are expended in the United States for twine made of Manila hemp, and of its cheaper rival, the sisal or henequen, which is the great money crop of Yucatan. In Japan abacá is used extensively to make strong paper for movable partitions in homes.

Henequen. The rise of the henequen or sisal industry, which with a few exceptions belongs at present solely to Mexico, came about when the self-binding reaper caused a new demand for cheap twine about 1880. This article of commerce was obtained from the long, tough fiber in the thick heavy leaves of the henequen plant, which grows wild over much of the dry limestone plain of Yucatan near Progreso. Henequen growing on a commercial scale soon became a capitalistic enterprise, the plants being set out three by ten feet apart in hand-made holes in the unplowable rocky soil by Maya laborers. Rival vegetation is chopped down with a machete until the plants are grown. After this they yield 10 to 15 leaves every six months for 10 to 20 years. One man with two assistants will cut, trim, count,

[22] Formosa and Japan have small areas planted. Production in Latin America, particularly Brazil, increased during World War II. Since coffee and cotton growers use so much, experiments have been carried on in Pará since 1930. Production in the Amazon Valley in 1943 was 11 million pounds and expected to reach 17 million pounds in 1944.

[23] The Japanese blockade of the Far East in 1941-45 caused a veritable fury of starting new industries in Middle America (including West Indies). When the Eastern coolies get to work again and the steamships resume, Tropic America will again feel the competition that kept it so flat in many exports of tropic agriculture before 1941.

tie into bundles (25-50 leaves to a bundle), and carry to a roadway 3,000 to 4,000 leaves a day. Tramways carry the heavy leaves to engine-driven machines that tear out the 3% (by weight) of fiber, which is then dried and pressed into 35-pound bales for shipment. In a few decades Yucatan has become the commercial slave of henequen, just as our South once was of cotton, this one product making up 95 to 98% of the export of Yucatan. This one money crop buys much of the food, even corn in considerable quantities being imported.

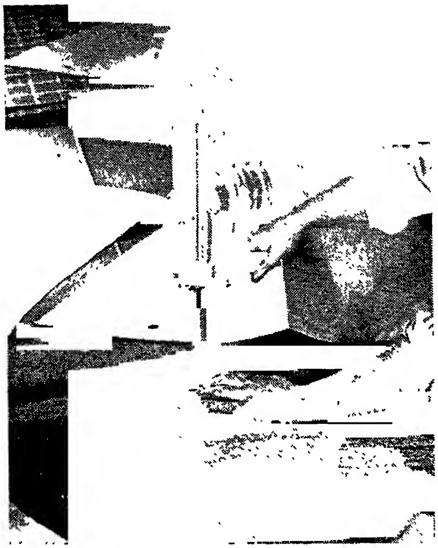
Every shred of the henequen fiber (called Mexican sisal) is exported, and virtually all of it is consumed by manufacturers of binder twine in the United States and Canada. Sisal does not make as good twine as Manila hemp, but it is good enough and usually cheaper. Therefore, nine-tenths of the binder twine used by the American grain growers is made out of Yucatan sisal. During World War I, when there were no ships to bring the rival hemp from Manila, the henequen dealers and the state government formed a trust and reaped a golden harvest by getting more than war profits.[24] The state and federal governments took heavy export taxes, over four cents American gold per pound. The postwar slump was shown by exports of 930,000 bales in 1920, and 460,000 bales in 1922. There are still many heavy export taxes levied not only by the Mexican but also by the Yucatan Government. The tax on henequen is much higher than on binder twine, while rope is exempt—an effort to encourage the national industry. Certain subsidies are also paid to the Henequenaros Yucatan, the trust that controls practically the whole industry. The total 1941 exports were almost 500,000 bales. The price in the years 1930-39 except for a low 1932-34 was around 6 cents per pound.

Cuba has the most promising rival henequen plantations at present; her half-dozen large plantations comprise about 33,000 acres. There are small plantings in Jamaica, Haiti, Tanganyika, and Mozambique. Elsewhere the henequen plant is rarely found even in botanical gardens.

Although botanists did not recognize it for some time, sisal and henequen are two different plants. Both were introduced into Florida in 1834, but only the sisal survived. When the selfbinder increased the demand for hard fibers in the 1880's, efforts were made to produce these in tropical colonies, but Yucatan would not permit propagating stocks of henequen to go out of the country. Bulbils of sisal growing wild in Florida are available at $4 per 1,000 and are the direct or indirect sources of commercial sisal outside Mexico. Sisal has been used most extensively in the longer binder twines. It has more tensile strength than henequen and is the most satisfactory substitute for abacá in marine cordage. It is also used for bags, bales, floor coverings, bristles, cheap twine, and upholstery tow. In 1939 the world production of 247,000 metric tons went principally to the markets of Great Britain, continental Europe, and the United States at about 5 cents per pound.

[24] When the trust was established in 1915 sisal was selling for 3¼ cents per pound; in July, 1916, the price had been forced up to 10½ cents; in January, 1917, the trust demanded and received 16½ cents per pound.

Coconut Fiber. The coconut, widely distributed along the tropic seashore, contributes to commerce the well-known hard-shelled nut, the dried coconut meat known as copra, and lastly the coir fiber, a part of the thick and spongy



Harry Rubenstein, ILGWU

The Machine Age goes to the clothing factory. This electric cloth cutter buzzes its way through 30 or 40 thicknesses of cloth, cutting out pieces for 30 or 40 suits that will all be alike. In a short time the pieces will whiz through the electric-driven sewing machines with a speed that would make the novice stand aghast.

husk which protects the nut from bursting when it falls from its great height to the ground. By soaking the husk in water, the pithy packing between the fibers can be washed out by hand or by machinery, leaving the stiff fibers which are used for making brushes and ropes very durable in sea water, and the coarse, strong coco matting so often used upon the floors of public buildings. Coir fiber is produced almost entirely in India and Ceylon. Production figures are difficult to estimate, since large quantities are used in village industry. India exports the fiber only in the form of yarn and other manufactures. Ceylon alone exports coir fiber; of the 36,000 tons exported in 1938, less than one-third was for bristles, the rest for mattresses.

Matting. The ordinary matting used as floor covering practically all comes from Japan and China. It is also a native product of the adjacent Tonkin or French Indo-China. The farmers grow a special kind of straw for the manufacture of this characteristic tropic floor covering.

9. *Commercial Clothing Manufacture*

Similar Development of the Textile and Clothing Industries. At the end of a century and a quarter of machine manufacture and world commerce, the making of clothing for sale passed through an evolution similar to that which has occurred in the textile industries. The cloth was at first made in the homes of the workers from materials which were given out on contract. Later the whole work was done in the large factory with the aid of machinery. Some clothing is now made by the old domestic system, some on contract in the homes of the workers, and some in factories and shops with the factory-made product gaining on the others.

The supplying of sailor's clothing was the start of the ready-made clothing industry. In 1850 the sewing machine opened great possibilities, which led to the widespread establishment of the industry in 1861-65, when the Civil War demanded ready-made clothing for millions of absent men. In the latter quarter

of the nineteenth century, the industry spread and located itself in the great cities. Great abuses arose through the "sweat shop," home work in crowded tenements, often at very low wages. Legislation, aided by the invention of factory machinery, has partly broken up the sweat-shop system, and factories now make clothing more cheaply than can the diligent workers toiling in their own homes at any fair wage. The first decade of this century was, as a consequence, a period of rapid increase in the manufacture of men's and women's ready-made clothing in factories rather than in sweat shops. In the sweat shop five persons usually work on a coat, each doing a particular part. In some of the great factories, as many as a hundred persons work on each coat, and the total amount of time required to produce a given output has been reduced to one-third or even to one-tenth of that required before the introduction of the greater division of labor, new cutting machines, and the electric-driven sewing machines.

Why It Is a City Industry. Clothing manufacture belongs to large cities because of the double advantage of nearness to labor and to market. Style is master. Few industries demand such intimacy between manufacturer and wholesaler. Style and quick delivery make it a great advantage for the factory to be close to the place where the product is sold, and the successful selling of ready-made clothing requires a market where vast numbers of persons are supplied, so that, by the law of averages, all of each of the many sizes of clothing may be called for. As the market widens it permits the finer and finer subdivision of the sizes, and the greater possibility of an exact fit for each person. The large city also possesses the labor which is so large a factor in this industry in which the transport of the raw material is so easy. The manufacture of clothing is concentrated to an astonishing but declining degree in the city of New York, the greatest distributing center of the United States, where it is the leading industry, with an output valued at almost $1.5 billion (1939), employing 43% of the city's wage earners, and producing 36% of its manufacturing total. This great predominance of New York grew up in large part because of the unusual labor condition that existed because it was the chief place for the landing of the new immigrant. Tens of thousands of these people knew nothing of the language and little of the country, and they were accustomed to low wages and inexpensive standards of life. The clothing factory, where each person does a small operation, offered these helpless ones an opportunity to acquire in a few days the skill to make a better wage than they had in Europe, so they herded together in the cities. In one block on Broadway, New York, covered with twelve-story structures, 40,000 people were engaged in manufacture, largely clothing, in 1910. No other city block in the world could rival this as a human hive, but it was no cause for pride. The industry in all the American centers has been usually carried on by foreign-born persons newly arrived in this country.

New York, accounting for 41% of the nation's clothing in 1927, declined to 34% in 1939. Meanwhile New Jersey, Pennsylvania, Connecticut, and Massachusetts climbed from 20.9% to 35.4%. California now does one hundred mil-

lion dollars' worth of business in women's apparel. St. Louis has developed one of the leading "Junior Miss" dress markets in the country. Kansas City, Dallas, Chicago, Philadelphia, and Boston have attained substantial outputs.

The standardizing of clothing is steadily advancing and with it new additions to the list of manufactured articles. Thus the small tailor is suffering from the competition of the great factory through the competition of made-to-measure mail-order business. By this innovation, a country merchant in Texas shows a book of samples to a customer, measures him, and the suit is made in a New York, Rochester, or Chicago factory.

There appears to be no reason why standardized clothing, like shirts, overalls, etc., could not be made to better advantage in small country towns where comfortable and wholesome living is cheaper than in the big city. Some such development has taken place in southeastern Pennsylvania, and it should spread.

Clothing Manufacture in the Old World. The use of ready-made clothing is less general in Europe than America, chiefly because the lower wages make it less necessary to use machinery. London occupies a position similar to that of New York, and the work is there done in the poorer or eastern end of that city by newly arrived immigrants of the same races of people who do the work in New York and Chicago. The only difference to point out in London and the large Continental cities is the greater proportion of sweat shops and the smaller proportion of factory workers as compared to American cities. But factory-made clothing is steadily advancing.

The increase in the use of ready-made clothing seems certain to continue, for it is attacking the market at the bottom and at the top. The people of Jerusalem, Constantinople, and Quito are reported as purchasing cheap hats, coats, and working clothes of European manufacture—Austrian, German, British, French. At the other end of the market is the well-known American advance in the quality and sale of factory-made clothes.

Manufacturing of clothing is increasing in the wool-manufacturing cities of Yorkshire. Factories there export the product to the British colonies and also make up clothing upon the specifications of tailors living in other localities. The people of Guatemala, for example, find that they can get suits made to measure in England and delivered by parcels post for only $2 more than it costs at home.

It is interesting to note that as Japan's industrial evolution advances along Western lines, a factory-made clothing industry develops there also.

The Fashion Industry. Paris, famed as an art center, and visited by thousands of moneyed people from all over the globe, developed a specialized type of clothing manufacture which utilizes both the artistic qualities of the French, and its own fame as the world's pleasure capital. Thousands of men and women earn their living by fashion alone, and all over France there are workers to feed the capital with material for what is in reality a national industry. Dress may be a frivolous pastime to the society woman, but to France it is a serious business. In the hands of Paris dress-

makers and costumers whose names are known to the wealthy in every land, the silks and fine linens from the French looms are cut and draped into ladies' gowns, new, beautiful and costly. The cunning touch of artist-milliners evolves Paris millinery, supposedly more stylish and desirable than the English or American product. The magic word "Paris" on ladies' clothing has come to imply both excellence and the latest style.[25] In 1922 France's three most valuable exports in order were silk fabrics, women's clothing, and cotton fabrics. However, by 1938 chemical products ranked first in value of exports; second were silk and cotton textiles (cotton being almost twice as high as silk). This is due in part to the competition of other fashion centers in the world which have challenged the leadership of Paris. Before and during World War II countries developed their own designers and fashion houses. Just as New York City has its postwar project of a World Fashion Center similar to Rockefeller Center, so Paris must have plans to regain its reputation. If it cannot, it will be one more in a long list of industrial victims of World War II.

[25] Years ago the late Oliver Herford wrote a delightful booklet called "The Simple Jography," with many apt summaries. "The French," he said, "are the Greatest Millinery Power on Earth."

Why Do We Trade?

Commerce exists because individuals and peoples, having different goods, exchange their surplus to mutual advantage.[1] This difference in the production of peoples arises from three main reasons—first, the difference in the peoples themselves; second, the differences in the stages of industrial development; and, third, the difference in the resources of their respective lands.

1. Differences Between Peoples

The first reason for a difference in production arises from a difference in the peoples themselves. The Japanese and Chinese export to other countries their porcelains, lacquer ware, metal work, fancy paper goods, and other products, which have their distinctive character and value because they reflect a skill peculiar to these Oriental peoples, whose culture is so different from our own. From India come many carvings and curios, which are prized as examples of Indian art. The chief commerce of some American Indians is in basketry, blankets, birch bark work, and other products of their tribal life, and native arts and crafts. Among the peoples of Western civilization, the French are conspicuous in commerce through the export of products which are valuable because of the French skill and taste which give them a superior artistic character and make them precious to the lovers of the luxurious and beautiful everywhere. Prewar German commerce reached an important position partly through the influence of the scientific attainment and thoroughness of the German people. This was particularly true of their leadership in the chemical industries and the industries that have through their chemical basis a close dependence upon the laboratories of a nation which has led the world in chemistry, and also in the teaching of other sciences. Scores of young Americans went to German universities every year to study science.

The mass production of the American automobile and other machinery has results in cheapness and efficiency and foreign trade that rival German chemistry as a factor in winning trade. In the first instance, it is a result of the size of the market, really the number and wealth of the American people. Little Belgium just hasn't the chance to start such an industry.

Political and Social Conditions. Production and trade are vitally affected by the kind of government under which men live. Trade is hazardous and more costly with a country that is disturbed by banditry, revolutions, and civil war. Under such conditions, production must

[1] For exhaustive analyses of the theory of trade, see Frank W. Taussig, *International Trade*, The Macmillan Co., New York, 1927; Bertil Ohlin, *International and Interregional Trade*, Harvard University Press, Cambridge, 1935; and Jacob Viner, *Studies in the Theory of International Trade*, Harper & Brothers, Publishers, New York, 1937.

remain at a primitive level, and the normal flow of trade is generally impeded by higher insurance and transportation rates, and if the financial stability of the national government is threatened, lack of confidence in the country's monetary system causes fluctuations in foreign exchange rates that may wipe out the profits of foreign trade. Unstable political conditions at various times in the past have seriously dislocated trade with China, most Latin American and Balkan nations, and many another country. A strong, honest, and stable national government, at peace with other nations and maintaining internal law and order, is obviously one of the basic conditions in which trade can thrive.

In contrast with the free and unrestricted flow of trade that usually occurs within the borders of each nation, international trade is impeded by a multiplicity of man-made barriers.[2] Many nations have endeavored to control their foreign trade through the use of tariffs, quotas and embargoes on particular imports, foreign exchange restrictions, currency manipulation, governmental support of cartels and price-fixing schemes, production subsidies, administrative favors, and many other devices. Such measures have been employed not only to give domestic producers an advantage over foreign competitors but also to discriminate in favor of one foreign nation and against another. These measures are often based upon the erroneous philosophy that my gain equals your loss, they disregard the basic principle that the benefits of trade are mutual, and they generally cause capital and labor to be diverted into high-cost industries in which a nation does not possess a natural advantage. To the extent that such measures reduce a nation's imports, they bring about a corresponding reduction of its exports, for no country can sell abroad unless it is willing to buy. In the interim between World War I and World War II such obstacles to trade became so numerous and widespread that the world community of nations began to resemble a checkerboard of high-walled estates much like those of the Feudal Ages.

The Wish for Self-sufficiency. While these obstacles have an important effect upon the character, volume, and direction of a country's foreign trade,[3] no nation on earth can hope to achieve complete self-sufficiency. The continued growth of international trade in spite of these man-made barriers shows that trade is both necessary and profitable. No amount of political interference can eliminate the economic interdependence of modern nations; it is only making many economic monstrosities.

In general, it may be said that trade flows more freely between countries that have similar social and cultural characteristics as, for example, between the

[2] See Margaret S. Gordon, *Barriers to World Trade,* The Macmillan Co., New York, 1941; Josef Grunzel, *Economic Protectionism,* Oxford University Press, New York, 1916; and John B. Condliffe, *The Reconstruction of World Trade,* W. W. Norton & Co., New York, 1940.

[3] For example, under American tariff policy complete freedom of trade exists between the United States and its overseas possessions, but foreign goods entering these possessions must pay the import duties that are prescribed in American tariff schedules. The effect of this policy of "tariff assimilation" upon the direction of trade is shown in the case of Puerto Rico, which sells more than 98% of its exports to the United States and obtains about 91% of its imports from this country. Colonial trade has been monopolized in a similar manner by France, Italy, and Japan. Trade between Great Britain and its overseas dominions and trade between the dominions are favored by lower duties than those levied upon foreign imports.

United States and the English-speaking parts of the British Empire. While differences in language, literacy, religion, culture, and local customs and prejudices create problems that call for skill, tact, and ingenuity on the part of exporting firms,[4] such differences among the peoples of the world are seldom insuperable barriers to trade. They do, however, interfere with or delay the working of the three main forces mentioned in the first paragraph of this chapter. At first thought it may seem that the difference in the skill, genius, or culture of races is the greatest cause of trade; but this is not the case. Racial difference is the least important of the three main causes.

Will Cultural Differences Last? Racial differences and their various commercial results are conspicuous for their tendency to be evened up and to disappear. The relative advantage of German scientific leadership has largely disappeared because of the increase in scientific instruction and technical training in the United States, Great Britain, and other countries. The Germans taught us freely, for a time, in their universities. Only an expert can distinguish between a costly, hand-woven Persian rug and some of the clever imitations that are now manufactured with power-driven machinery. In Japan, the making of art products is declining because of the copying of European and American machine manufacture under the factory system; and machine-made cotton, Western style, becomes a staple Japanese export. The arts of the Indian and the tribesman everywhere tend to vanish before the machine-made product of world commerce. This is usually a great blow to tribal life and native culture.

It is more than possible that extremely specialized complicated assembly-line mass production may long survive because of its mere size and the very special conditions under which it can thrive.

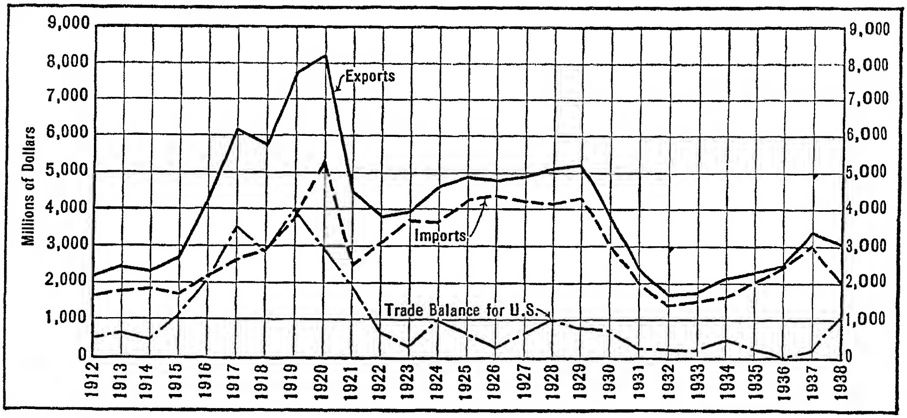
2. *Differences in Stage of Industrial Development*

We have seen that certain climates of the temperate zone are far more conducive to physical and mental activity than others,[5] and to the extent that racial differences are the result of climatic causes they are apt to remain of permanent importance. On the other hand, we know that the color of a man's skin has nothing to do with his ability to learn provided that he has the opportunity. The successful development of a steel industry at Jamshedpur, India, with exclusively native capital, labor, and initiative and the migration of the cotton textile industry from its English home to the far corners of the world demonstrate the fact that brains, ability, and skill are not the monopoly of any one country or race.

The second cause, a difference in the stage of industrial development, is much more important in explaining

[4] American manufacturers have long found it worth while to install right-hand drives in automobiles destined for sale in Great Britain, Australia, Chile, and a few other countries where the custom is to drive a car on the left-hand side of the street or road. Typewriter manufacturers have devised foreign language keyboards to meet a great variety of needs. John Higgins Williams, former American vice-consul in Ceylon, relates that Ceylonese hens lay small eggs and that some years ago German manufacturers complied with a request to produce smaller egg cups whereas British manufacturers declined to make such a change, with the result that all egg cups sold in Ceylon were imported from Germany.

[5] *Cf. supra,* pp. 13-16.



This graph, showing the United States total trade with the world, 1912 to 1938, is a record of near lunacy and certain tragedy. The United States of America seems to have been working on the same intellectual level as the dog who dropped a good bone to reach for the reflection of said bone in the water. Our foreign trade legislation seems to work on the concept that trade consists of exports, which are a virtue and that imports are a sin. Thus we had established foreign credits in World War I and then put up tariffs to keep the foreigners from paying us in goods, which was all they had to give. This is all evident in the three exceedingly significant lines of this graph. When we finally quit lending money to Europe, 1929 was here and the bubble burst.

the world's present commerce than are racial, political, and social differences. The difference in the stage or intensity of industrial development is largely a matter of the density of population. Two people to the square mile will inevitably support themselves by means which differ greatly from those that will be adopted by 200 people per square mile in the same kind of territory. For its exports the sparse population seizes upon the raw products of nature, or produces raw materials requiring the least labor. A dense population, having few raw materials per capita, must fabricate them to a higher degree to make value. In the new forest lands, one person to two or three square miles may make a satisfactory living by the trapping of fur-bearing animals and the gathering of nuts, gums, herbs, and roots. A population slightly more dense will cut down the forest and sell logs as lumber. If this sparse population is upon the open plain, it will employ itself in tending herds of sheep and cattle and will export wool, hides, and animals. If the population increases and the climate is suitable, the level plain will be carelessly plowed up and sown to grain, which will be exported to the densely peopled region.

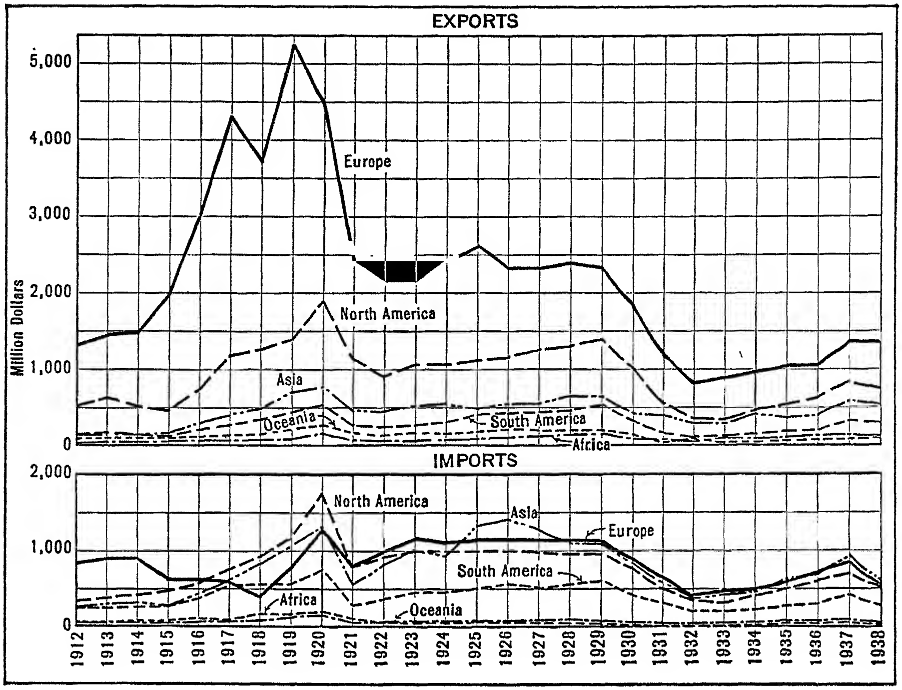
This, in brief, is the explanation of the great commerce of the second half of the nineteenth century. The European peoples settling the comparatively empty lands of America and the antipodes have been producing wheat and sending it back to the better-yielding wheat lands of Europe; they have been sending cattle, meats, and dairy products to the European countries, where the pastures are fatter and cattle more numerous per square mile; they have been exporting lumber to the countries where the forests are better kept, because the European population is dense and the American population has been

and still is relatively scanty. This is the chief explanation of the commerce between the German-American in Wisconsin, the Scandinavian-American in Dakota, or the Anglo-American in Kansas, with their kinsfolk in the old country. We even send to and get from Europe articles of the same material but of different degrees of manufacture. Thus we export raw cotton and buy fine fabrics and lace; we export logs and planks and import wood carvings from Switzerland and the Black Forest region of Germany; we export sole leather and import the fancy tans of France and Germany; we sell steel rails and pig copper and buy English cutlery and Swedish scientific instruments; until World War I forced us to develop a dye industry of our own we even sent coal tar to Germany and brought back the drugs and dyes that her chemists made from it.

Owing to the westward movement of peoples and the development of dense populations around the coal fields of western Europe, we see within the Old World itself a duplicate of the trade that passes between America and Europe. The densely populated manufacturing parts of Europe, west of Stockholm, Danzig, Cracow, and Budapest carry on a most active commerce with the territories of the Baltic and Black Seas, deriving from them foodstuffs and raw materials often identical with those that come from across the Atlantic. These manufacturing regions have been sending to us and to eastern Europe woolen goods, cottons, silks, leather goods, machinery of many kinds, metal manufactures, cutlery, gloves, lace, and the thousand products which reflect the much labor and the relatively small raw material of densely populated regions. Likewise, the newer outposts of Western civilization in Australia, New Zealand, South Africa, and Argentina are to manufacturing Europe merely grain fields and sheep and cattle ranges, inhabited by people who buy their manufactured goods and pay for them with grain and animal products. Such trade will appear wherever these differences of population are found and land permits.

Trade based upon differences in the stage of industrial development, like that depending on racial differences, from which it cannot completely be distinguished, has a strong tendency to disappear through the equalizing of industrial conditions throughout the world. Thus, the United States and Germany, once heavily dependent upon Great Britain for manufactured goods, developed industries of their own, and today the United States is the world's greatest manufacturing nation while Germany became one of Britain's leading rivals. In this consideration we should not confuse *amount* with *percentage*.

Within the United States itself the whole development is shown. New England has duplicated old England in more than name. Like England, it is little more than a group of towns and cities whose people live by fabricating raw materials, most of them imported, and sending the product chiefly to the West and South in return for the food and raw materials of those newer and less populous sections of the country. The lower Great Lakes region, which, 75 years ago, was to New England both market and source of supply for food and raw materials, has come to surpass New England in manufacturing and



United States exports and imports by continents, 1912 to 1938. All lines have zero for the base. The overwhelming importance of Europe in our trade is manifest even in times of heavy depression. We can plainly see the results of World War I, our donations of food for a year afterwards, Europe's heavy borrowing for another year and moderate borrowings for several years more. The lean years of the 1930's are certainly a call to the human intelligence to learn more about distributing the produce of industry. This book has shown how *production* has been mastered.

turns for supplies to the yet newer West and to foreign lands. The cotton textile industry of America, once centered in New England, has been built up on an even larger scale in the South; and all kinds of manufacturing is going on in greater and greater quantities west of the Alleghenies, so that the North Central States are coming to resemble New England as New England has come to resemble old England. Furthermore, the Pacific coast has become less dependent upon the industrial East as the result of the expansion of manufacturing in the Los Angeles, San Francisco, Portland, and Puget Sound areas. As both New England and old England have been confronted with growing competition from newer manufacturing areas, they have seen many old markets dwindle and disappear, and they have been forced to turn increasingly to the manufacture of high-valued goods requiring skill and long experience in production.

We can see that as a nation's population continues to grow, thereby increasing the domestic market and labor supply, as local capital accumulates, and as transportation facilities are expanded and improved, the inevitable result is a more intensive use of human and natural resources. This normal economic evolution is accompanied by a growth

of manufacturing if the fuel, market, raw material, and other factors are favorable. It is undoubtedly true that the great influx of European immigrants, reaching a peak of more than a million persons a year prior to World War I, did more to accelerate the development of manufacturing, agriculture, and mining in the United States than did all the protective tariffs ever passed by Congress. Population growth is the prime force that helps to level differences in the stage of industrial development among nations.

Apparently every state in the Union and almost every country in the world wants to have manufacturing industries.[6] In recent decades Canada, Australia, South Africa, Argentina, Chile, Brazil, Mexico, Japan, and other countries have resorted to high tariffs and other devices to foster the growth of domestic manufacturing. In many cases high-cost industries based upon mediocre resources have been created that could not continue to exist without the tariff's protection against the competition of cheaper foreign goods. Whether manufacturing is the hot-house product of governmental aid or whether it arises in the face of world competition, its widespread development in many countries has resulted in the decline or cessation of many branches of international trade. It hastens the leveling up and sometimes produces artificial heights in the place of natural levels.

This tendency to the leveling of industry shows in its early stages a growing tendency for producing areas to perform one or more steps in the manufacture of raw materials and crude foodstuffs prior to exportation, for example, to ship smelted and refined metals instead of ore, lumber instead of logs, quebracho extract instead of quebracho logs, leather instead of hides and skins, coconut oil instead of coconuts and copra, refined instead of raw sugar, and flour instead of wheat. As a result of this tendency, the producers are able to reap some of the gains of trade and also share the profits of manufacturing.

3. Difference in Available Resources

Nature had a large deck of cards marked as follows: Good coal, medium coal, poor coal, peat; rich soil, medium soil, poor soil, clay soil, sandy soil, rocky soil; and so on through a hundred kinds and qualities of natural resources. She dealt these cards out to the nations in such a way that there is a tremendous variety in things that come to man's hand to aid him in producing the useful commodities in the different countries and regions of the world. Difference in resources in the different countries makes trade inevitable, if there is to be anything approaching equality of consumption and comfort among the peoples.

Topography. Although the greatest development of agriculture, manufacturing, and commerce has always occurred on the plains, differences in topography give rise to a trade which will endure. It is true that the mountaineer who ekes out an existence by cultivating a little patch of thin, rocky, and easily

[6] For an account of the recent rise of interstate trade barriers in this country, see F. Eugene Melder, "Trade Barriers between States," *The Annals of the American Academy of Political and Social Science*, vol. 207, January, 1940, pp. 54-61, and Cordell Hull, "Trade Barriers at Home," *State Government*, March, 1939, pp. 45-46.

tina, and southeastern Australia (see Figs. 407A and 401). While such examples are conspicuous, they clearly reveal the important effect of soil differences upon agricultural production and trade.

Climate. Differences in moisture give us the humid and the arid lands between which there is a great and growing trade. Beyond the bounds of cultivation in all countries are the sheep and cattle ranges, where the sparse population has two or three products to sell, and must buy most of its food from more favored farm lands, and must secure from the manufacturing towns all the other products that are to be purchased in the store. In the irrigated oases of the arid lands, dried fruit is produced most easily, and it is being sent from these favored spots in Australia, in Argentina, in Chile, in Europe, and in the United States to the more humid districts, which can with ease produce other products for exchange. This exchange of dried fruits and animal products for grain and manufactures is worldwide and seems to be as enduring as the variation in rainfall, the distribution of people, and the ability to transport with ease.

Temperature as a basis of trade is perhaps the most fundamental, the most widespread, and, for the future, the most promising of great and yet greater performance. No exchange of culture, no equality in education or skill, no emigration of peoples evening up density of population can change the temperature and make tropic fruit grow in the land of arctic fur, or cotton grow in the land of spring wheat. If America becomes a second Europe, Manitoba will have a lively trade with Texas, because Texas can produce cotton and other sub-tropic products, which the short summer forever bars from Manitoba. Florida and other southern lands will send their oranges and vegetables to the northern lands of frost when the latter's agriculture is frost-bound, and the North will send in return its wheat, the red apples from its hills, and the myriad products from its factories and mills. Examples in miniature often permit us to see the tendencies of the time more clearly than larger and more complicated examples. Thus the Canary Islands, snugly fixed on steamer routes in the frost-free waters of the warm Atlantic, have developed an export of over 400,000 tons per year of bananas, tomatoes, potatoes, and onions, chiefly to the urban markets of Great Britain.

This north-south trade has grown rapidly in recent decades and will continue to increase in the future.[9] It gives the things we cannot ourselves produce, and is needed to round out the economic life of northern and southern lands alike. Foods make the most important class of commodities from tropical and subtropical lands. Northern peoples want

[9] The importance of our trade with tropical and sub-tropical lands is shown by the fact that in 1935-39 crude rubber and latex, cane sugar, coffee, and raw silk accounted for approximately 24% of the value of our total imports, and in 1940, about 27%.

VALUE OF SIX PRINCIPAL IMPORTS OF THE UNITED STATES

(In millions of dollars)

	1935–39 (average)	*1940*
Crude rubber and latex	167.0	318.5
Cane sugar	142.0	113.3
Coffee	139.7	126.8
Newsprint paper	103.7	124.7
Raw silk	102.9	125.0
Tin	73.0	128.3

their cane sugar, cacao, coffee, rice, spices, bananas, and other fruits; their coconuts, Brazil nuts, palm nuts, tapioca, and many minor foods. We of the temperate climates want, for our mills and factories, their raw materials, rubber, Manila hemp, jute, henequen, and other fibers; their cabinet and dye woods; their rattan, gums, palm oil, and other forest products. In exchange for these, the northern lands are sending machinery, clothing, and all kinds of manufactures and some foods, such as wheat and potatoes. This is a natural trade.

Minerals. The primeval gods of geology were not democrats, or they would have dealt out mineral resources to the nations with a greater sense of equality. Some nations got aces, kings and queens. Some scarcely got deuces and are but beggars in this, the age of minerals. The general pattern of international trade is profoundly affected by the fact that a few nations have exceptionally easy access to large deposits of coal and iron, basic resources underlying our modern Machine Age. Peerless access to the world's prime source of energy and to the greatest of all machine resources has made the United States, Great Britain, Germany, France, and recently Russia the world's leaders in manufacturing and has enabled a high development of the factory system in the smaller countries of Belgium, Poland, Czechoslovakia, and Austria.[10] Particularly in northeastern United States and northwestern Europe manufacturing and trade have contributed to the growth of dense populations with a high purchasing power per capita. These two areas are the greatest markets on earth for the exports of many lands. To the towns and cities of these two areas are carried the great bulk of the world's petroleum, copper, bauxite, tin, nickel, lead, zinc, and other minerals. To these markets move the great bulk of the world's lumber, fibers, leather, rubber, and other raw materials. To these markets are shipped vast quantities of grain, meat, sugar, and other foodstuffs to feed the millions of men who work in the power-driven factories, mills, and the coal-heated offices in thousands of towns and cities. From these two great industrial and commercial areas are shipped myriads of manufactures to the far corners of the earth. Just as at one time in ancient history all roads led to Rome, so today the major trade routes of the world focus upon northwestern Europe and northeastern United States—the centers of coal and iron.

While the mining of most minerals is widely distributed throughout the world, in terms of volume of output the bulk of production occurs in a few countries (see Table 16). Thus, coal and lignite are mined in more than 50 countries, but the United States, Germany, Great Britain, and Russia regularly produced at least three-fourths of the world's total supply before 1940.

Iron ore is mined in some 45 countries, but the United States, Russia, France, Sweden, and Great Britain account for nearly three-fourths of the world's output. The United States has a virtual monopoly in molybdenum, al-

[10] Indeed, more than 90% of all industrial energy derived from coal, petroleum, and water power is consumed within a long but by no means unbroken belt that extends roughly from Chicago to Magnitogorsk.—See Charles K. Leith, James W. Furness, and Cleona Lewis, *World Minerals and World Peace*, The Brookings Institution, Washington, 1943, p. 32.

though 15 other countries are engaged in production. Again, while 17 different countries mine nickel, Canada and New Caledonia produce 93% of the total supply. This concentration of mineral production obviously increases the necessity of international trade. Furthermore, mineral deposits vary greatly in size, richness, purity, physical accessibility, and nearness to market and transportation facilities. Such differences determine the profitability of mining, they go far to explain the present location and concentration of production, and they vitally affect the volume and direction of mineral trade. It is because of such differences that some known mineral reserves lie virtually untouched, while others are of great commercial importance in supplying the world's present needs.

Mineral deposits lie buried in the earth, and there is always an element of uncertainty in production and trade as they pass through the stages of early rapid growth, maturity, decline, and eventual depletion. As mining operations in a given area go deeper and deeper and as reserves continue to dwindle, the cost per unit of output increases, and consumers are forced to turn to less expensive supplies. Thus, rising mining costs in Great Britain have contributed to the serious decline of British coal exports that has occurred since World War I. Production peaks are also past history in the petroleum industries of Pennsylvania, Ohio, Rumania, Poland, Mexico, and Peru. Most of the metals have residual scrap piles that give rise to an increasing trade in secondary metal, but coal, petroleum, gas, natural nitrate, phosphate, potash, sulfur, and most other minerals are in large part lost forever following their initial use. While some mineral resources may last for several thousand years at the present rate of consumption, the life span of others is measured in terms of a few centuries or even decades. In spite of the fact that new deposits of some minerals are still being discovered, decline and exhaustion are the ultimate fate of all mineral production and trade. The end result of the mining industry is an empty hole in the ground. The Germans call it the robber industry.

Size, Shape, and Location of Countries. Foreign trade, depending upon natural laws, modified by man's aid and interferences, is of varying importance in different countries, with the general tendency to be least important in large countries and most important in small countries. China peacefully and successfully ignored the foreign world for centuries, because she is a world within herself, reaching on the south to the latitude of Havana, on the north to the latitude of Newfoundland, producing cotton, rice and wheat, and reaching westward across semi-arid and arid pastures to the deserts of central Asia. For forty centuries or more, the world could give China very little that she wanted and could not produce, and she therefore scorned the world. Petroleum, cheap cotton cloth, modern machine manufactures, and new machinery have tempted the Chinese to buy, and their foreign trade is increasing, although in 1939 it amounted to only $1.10 per person. India, another large country but with more modern transportation facilities and greater political stability than China, has a per capita trade of about $3.25. The foreign trade, however, of a country like Uruguay, a little fertile

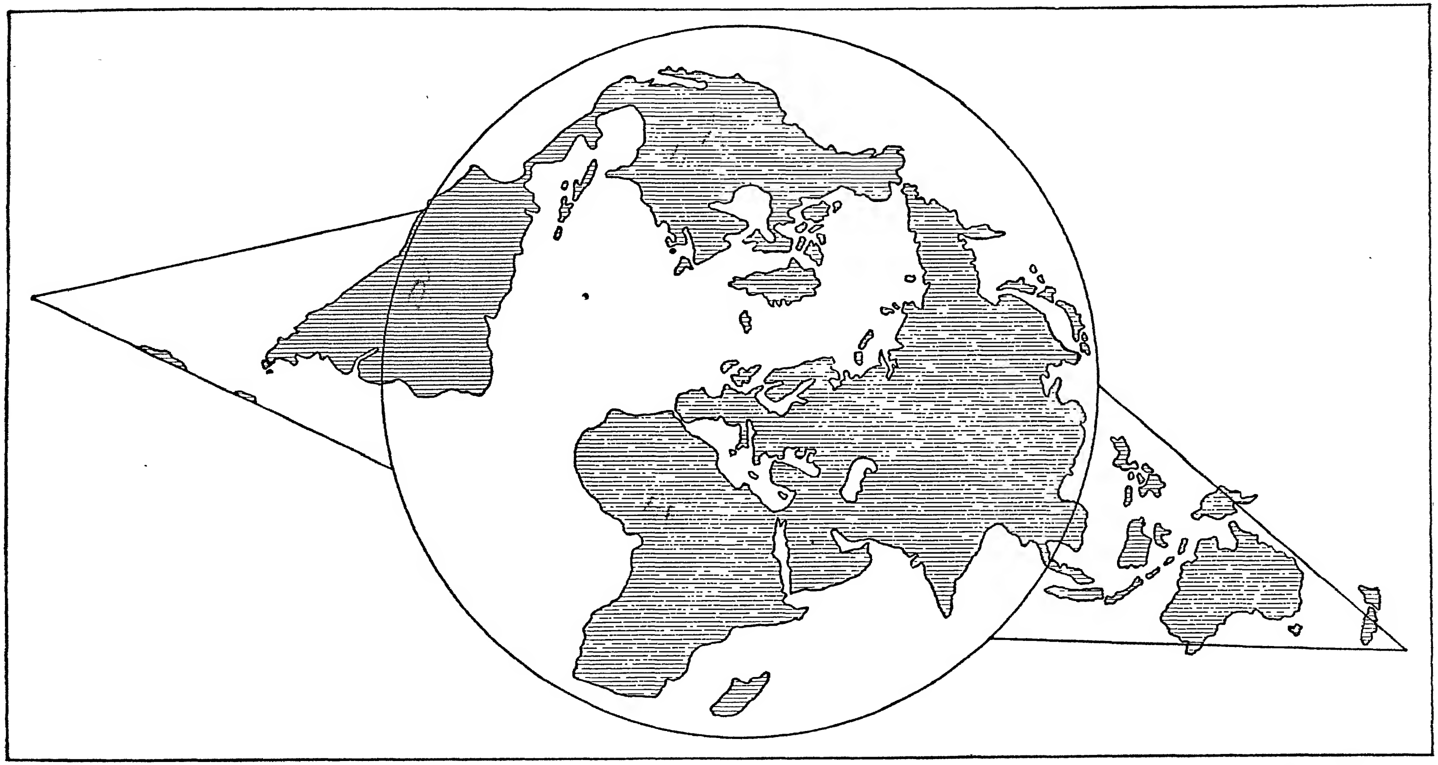
cattle and sheep ranch, is about $39 per person, because Uruguayans produce essentially one class of articles, with which they must buy everything else which a civilized people consumes. Small countries like Switzerland, Belgium, and Holland, with almost no variety in climate, and small variety of resources, have a relatively enormous foreign trade. So does Great Britain. So would New England, if we had the figures of commerce that cross her southern and western boundaries, but most of New England's trade is with other states of the Union and disappears without statistical record in our vast domestic commerce. If all Europe were but two nations, corresponding to the United States and Canada, most of her astonishingly vast foreign commerce would disappear, because the commerce of Great Britain or Germany with southern Europe and Russia would be like that of our northeastern with our southern and western states. Our great area and variety of resources give us a smaller per capita foreign commerce than that which is shown by the countries of Europe, especially such small countries as Denmark, and also by such little nations as New Zealand and Cuba.

To see commerce in its extreme development we should look at the Falkland Islands, a wind-swept sheep-range and whaling station with an area of 4,600 square miles, and a population of 2,800 people, whose foreign trade is approximately $1,900 per person per year. This surpasses the little French colonies of Miquelon and St. Pierre—a few thousand fishermen and ship outfitters on two barren rocks in the cold Gulf of St. Lawrence, who import and export each year the remarkable total of about $360 for every person in the colony.[11] In contrast to this, the per capita foreign trade of the United States is over $60, and that of Great Britain about $130 per year.

The size of a country, through its effect upon internal transportation costs, is also a factor in the trade situation. Thus, no point on the island of Great Britain is farther than 70 miles from the sea, and a similar advantage to commerce is also enjoyed by Japan. In contrast, products from the interior of such large countries as the United States, Canada, Russia, China, and Australia must travel many hundreds of miles to tidewater, a fact that adds considerably to the cost of the goods particularly when inland waterways are not available to carry the goods cheaply down to the sea.

The shape of a country may have an important effect upon trade. A highly indented coastline with many deep arms of the sea, providing an abundance of harbors and deep penetration of the land, is obviously an asset to commerce. In this respect no continent equals Europe, which for centuries has had a flourishing coastwise trade, while ships must unload beyond the pitching surf along thousands of miles of African beaches. The great maritime nation of Norway has long profited from its

[11] These per capita data show that the people of some countries are far more dependent upon foreign trade than others. However, they do *not* reveal anything about a country's prosperity. Thus, a low standard of living prevails among the Falkland Islanders and the inhabitants of St. Pierre and Miquelon, which have a very large foreign trade per capita, and also among the peoples of China and India, where the value of foreign trade per person is small. Furthermore, per capita data do *not* indicate the importance of a country's foreign trade in comparison with that of other nations.



Pole centered map of the world, but London is the pole. The pole centered map of the world that was so widely shown in the United States from 1940 to 1946 was about the worst possible exaggeration at the South Pole, where the Antarctic continent showed as a rim clear around the whole circumference. This map has the same scale in the "northern" hemisphere and those parts in the "southern" hemisphere which are shown. There is some exaggeration increasing from the pole to the "equator" and decreasing again as we proceed from "equator" toward "south" pole.

This map shows how closely London is actually situated with regard to the center of the earth's land mass. It also shows the basis for Mr. Stefansson's claim that the Arctic Ocean should not be called an ocean, but a sea—the *real Mediterranean, indeed.*

fjord coastline and the protection offered to navigation by numerous offshore islands. The peoples of narrow peninsulas and islands also have the advantage of short distance to the sea. For example, the "string bean" shape of Cuba, which has more than a hundred good harbors along its 2,000 miles of sunken coast, is a distinct commercial asset because sugar and other products for export seldom have to be transported more than 50 or 60 miles by rail.

The location of a country or region is one of the most obvious of all factors that may help or hinder its trade. Look at a globe and note the location of Britain in the center of the land mass. The United States is not far away and these two countries have an advantage of proximity which helps them to surpass all other nations in total volume of foreign trade.[12] The proximity of Cuba to the United States causes us to take a special interest in that island; we have large investments there, and we grant lower import duties on Cuban products than are levied on the goods of any foreign country, with the result that more than three-fourths of the island's foreign trade is with the United States.

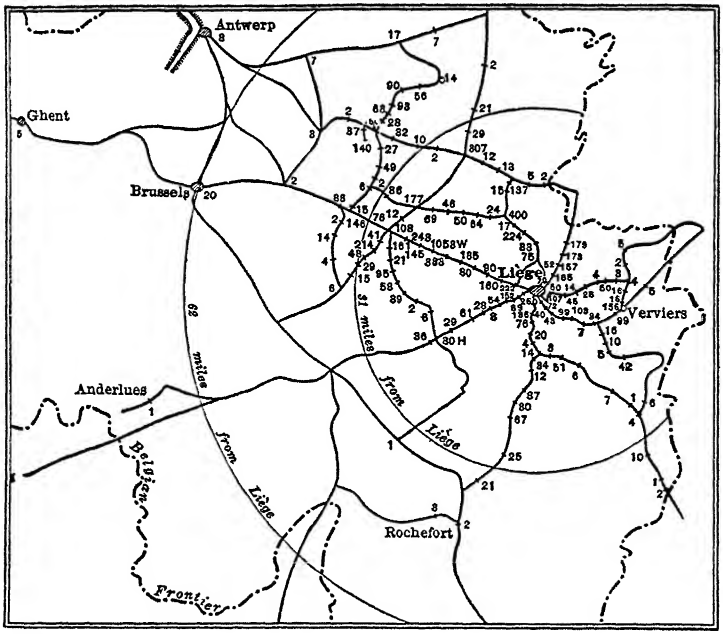
Finally, it should be emphasized that no one environmental or human factor is ever the sole cause of production and trade. Thus, location is merely one element of environment which, in conjunction with other environmental and human factors, helps to determine the character, volume, and direction of international and interregional trade.

4. Future Trends of World Trade

Although both man and his environment are subject to change, nature is far more stable and predictable than man. In any appraisal of the future of world commerce, it is clear that environmental and resource differences among nations and among regions are far more constant and permanent than human differences as a basis of trade. It is true that even land forms, bodies of water, and climate are subject to change, but the rate of change is usually very slow. Soils, forests, fisheries, and wild animal life may be depleted through human use and abuse, but under wise management these environmental assets can serve man in perpetuity. It is true that mineral deposits are exhaustible, but it is difficult to estimate their life span. Our knowledge of mineral reserves in many countries is far from complete, but we do know that they differ, for our time, almost like zero and infinity. In terms of human use, however, mountain and plain, ocean and land, seacoast and interior, forest and grassland, desert and swamp, arctic cold and tropic heat are forever different. Environmental contrasts give rise to trade that is far more enduring than trade based upon differences in race, culture, technical skill, political and social conditions, and other differences among peoples. Experience has shown that human differences frequently diminish and disappear.

Temperate-zone Trade. The trade of the present is predominantly between

[12] *Cf. supra,* pp. 17-19. In 1939 the total value of the merchandise exports and imports of the United States was $5.5 billion, as compared with $3.6 billion for Great Britain. In the interim between World Wars I and II, American foreign trade reached a maximum of $13.5 billion in 1920 and a minimum of $2.9 billion in 1932, while British trade fluctuated between $12.8 billion in 1921 and 3.5 billion in 1934.



If we can have the common sense to maintain peace and remove the fear of war there will be constant pressure to reduce man-made barriers to trade. In such a situation we may expect the lands with the best climates for human health and energy to forge ahead and develop communities something like that of which Liege, Belgium, is the center.

This map shows the distribution of city workers of Liege to village homes. Figures represent number going from each station to Liege. By trades: miners 1,832, factory men 2,871, building trades 1,440, unskilled 1,493, dressmakers and milliners 360, apprentices 242, other trades 1,167, railway workmen 520; total 9,925, of whom 5,830 went daily and 4,095 weekly.

These figures are for the week June 1-5, 1906, and are from the book, *Land and Labor,* by B. S. Rowntree. Examination of the map and the data shows the vast amount of work and other difficulties that would be involved in doing it over for another period. Belgian authorities assure us that the policy continues, with the encouragement of the powers that be.

Belgium is ahead of any other western nation in the scientific utilization of her land resources. Her factory workers live upon the land to a degree unknown elsewhere. On his plot of ground there is room for production by the aid of women and children, old persons, and the spare time of the artisan himself. This garden and orchard product, the poultry, hares, and possibly the cows are great additions to the total wage and they help to give large return per unit of land and to explain the dense population of Belgium.

This village worker has better home surroundings, social surroundings, and sanitary surroundings than many with larger cash incomes who live in solid rows of houses or in apartments in cities in the U. S. A. and elsewhere. The automobile is enabling this process to advance informally in the United States.

The proper use of this world should mean that unpleasant places like the Great Northern forests and unwholesome places like the Equatorial forests should have relatively sparse populations producing raw materials to be fabricated in lands of health, pep, energy and comfort.

temperate-zone lands in different stages of industrial development. To the extent that such trade is based upon differences in natural resources, this trade will tend to be permanent. The temperate semi-arid plains of every continent, wherever it is too dry to grow crops, will probably always have pastoral industries shipping out animal products to the more densely populated lands of the world. The Buffalo-Pittsburgh-Chicago triangle, the black country of middle England, the Ruhr Valley, and the new Ural industrial area of Russia will continue to be great manufacturing areas as long as they have easy access to iron and coal. The fertile black-earths of sub-humid parts of the United States, Canada, Russia, Argentina, and Australia will probably always produce and ship out grain. Our southern states, with a climate conducive to rapid tree growth, will be cutting and shipping timber when many other supplies are gone. Production and trade based upon environmental and resource differences are among the most permanent of human achievements.

On the other hand, differences in the stage of industrial development may be due chiefly to non-environmental causes, and such differences among nations and among regions often dwindle and disappear. For decades old England and New England have reaped the advantage of an early start in manufacturing, an advantage that must continue to wane in the face of growing competition. Only recently Russia has turned to a systematic exploitation of her natural resources, and in a remarkably short time she has emerged from the ranks of weak manufacturing nations into the ranks of the industrially great. Already Russia has less need for many manufactures of western Europe and the United States just as decades ago American dependence upon certain British manufactures underwent a decline. Orientals time and again have demonstrated their ability to acquire the simple industrial skills first developed to a high degree by factory workers in the Western World. If China should develop manufacturing on a large and modern scale, utilizing her limited coal reserves, local and imported iron ore, and her tremendous labor supply, such a development could not fail to have important repercussions in world trade. On the other hand, no truly great development of manufacturing can be foreseen in such countries as Australia, Argentina, and Brazil, where many industries must have tariff protection or perish. While trade based upon human differences has a tendency to decline, human wants and abilities throughout the world are constantly changing, and history will never record the time when all peoples are alike.

Trade with the Tropics. The twentieth century has witnessed a great expansion of trade between temperate-zone lands and those of the tropics. Frost-free tropical lowlands have the distinctive advantage of perennial plant growth, for temperatures are high and subject to very little seasonal change.

Billions of dollars of European and American capital have been invested in tropic plantations employing native labor to produce rubber, coffee, tea, cacao, cane sugar, spices, quinine (cinchona), bananas, pineapples, palm oil, palm kernels, copra and coconut oil, sisal (henequen), abacá, and other products for export. This capitalistic invasion of the

tropics has resulted in the creation of large, scientifically managed, agricultural enterprises that turn out a dependable supply of products of dependable quality. Furthermore, as never before, independent native farmers are devoting a part of their land, often too much of it, to the production of cash crops destined for distant overseas markets. The export of products of tropic agriculture to the temperate-zone markets of the world is an enduring trade that will undoubtedly increase in the future.

Whether many large and sparsely populated lands within the tropics will ever support a dense population is a moot question. It is a fact, however, that the hot and humid lowlands, enervating to most white men, have been avoided by the millions of emigrants who left Europe in search of new homes during the past and present centuries.[13] Tropic Africa is a colonial appendage of Europe, and immigration laws at present prohibit or restrict the entry of Orientals into Australia and the nations of North and South America. Through the course of centuries dense populations have developed on the more fertile soils in the lands of the monsoon in southeastern Asia. This is the only major agglomeration of population within the torrid zone, but the Negro has already filled many West Indian Islands to the bursting point, i.e., Barbados. Furthermore, most people think of the tropics in terms of steaming humidity, but there are vast areas of tropical desert and semi-arid land (see map of Climatic Regions of the World, inside front cover) that will never support dense populations.[14] These are facts that cannot be ignored in any appraisal of tropic potentialities.

[13] Scientists are unable to agree why white settlers have generally failed to colonize the tropics, whether they are beginning to make progress, and whether they can hope for ultimate success.—See A. Grenfell Price, *White Settlers in the Tropics,* American Geographical Society, New York, 1939.

The astounding, not to say alarming, increase of population in India, Java, and the West Indies is very suggestive of what may happen in an era of scientific sanitation and nutrition combined with air conditioning.

[14] The density of population of a country or a region reveals nothing about the pressure of population upon available resources and nothing about per capita wealth, per capita purchasing power, or the standard of living. The real figure is not population density, it is the amount of *resources* per person.

. . . 24

The Trade Center and Its Development

1. The Development of Commercial Centers

The Origin of Towns and Cities. The great currents of international trade always pass from one city to another, and the same condition is also true of domestic trade. Cities and trade are continually exerting reflex influence, the one upon the other, and, to understand the large commercial movements, we must understand the economic functions and origins of the city.

The origin of the town goes back into the early history of the human race—before the days of the first permanent settlements and the first regular trade. There are places in Asia where people still congregate for a temporary residence and season of trade—a temporary town whose people disperse to the four corners of the compass when the market adjourns. The present-day metropolis is but a town grown permanent through regular trade, and large through much trade, and the same laws govern its growth and push it from its village beginning to its metropolitan ending.

The beginning of commerce is a barter between two individuals. Each has a surplus of a particular article and each finds advantage in the exchange of that surplus. The most complex phases of present-day commerce are but the outgrowths of this simple exchange of goods, complicated by the numberless wants of man, the variety in natural resources, the world-wide distribution of industry, and the myriad complexities of invention and manufacture.

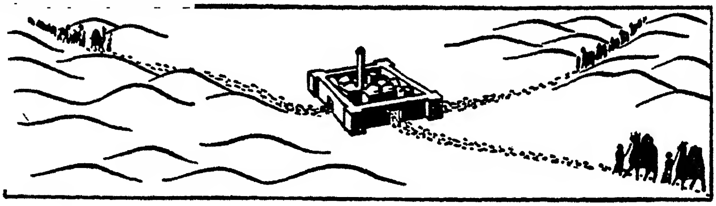
The rise from barter to money and the expansion of trade to international proportions have produced many institutions. First and most fundamental among these is the trade center, or collecting and distributing center. Granted riches and neighbors, trading man soon develops so many wants that it becomes inconvenient to visit individually the various people with whom he wishes to trade, and some common meeting place is the result. Many previously isolated individuals now have a place for common activity; some of them a place for common residence; and a market place or fair, a village or a town comes slowly into being. It is interesting to note in this connection that in many European cities this plot of ground where the primeval trading took place continues to this day as a market square, as in Antwerp, Brussels, and many other cities now grown great. It is also to be found in many a small European country town. The normal trading town is, therefore, manifestly and most naturally located in some spot easy of access, some spot with a superiority of access usually

due to geographic causes. If the superiority of access is sufficiently great, the settlement around this market place becomes a city with international trade, for the market village and the metropolis are alike the products of economic forces that differ only in degree, not in kind.

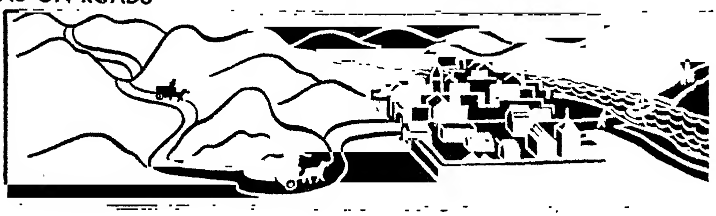
The Kinds of Cities. In examining into the causes for the growth of commercial centers, one should note the distinction between industrial and commercial causes—between industrial and commercial cities. Examination shows that most cities have both commerce and manufacturing in some degree. The mere numbers of people inevitably produce a certain minimum of trade and manufacture. As a commercial city increases in population, some local industries usually spring up. And similarly the growth of a manufacturing city usually develops some commercial activity. But, in the main, the city exists because it is either a commercial or an industrial center, the one activity being only secondary or tributary to the other. In many cases it is easy to characterize the world's leading cities as belonging to one or the other of these classes. For example, Pittsburgh, Pa.; Birmingham, England; and Lyons, France, will be classed at once as primarily industrial cities. New York, Liverpool, Hamburg, and Hongkong will be classed as predominantly commercial cities. The purest examples of commercial cities are to be found in places that are merely points of transfer, bulk-breaking points where the mode of transportation changes. At such points the conditions of life are sometimes so difficult that only the most compelling operations are performed, as in the hot, humid, and unhealthy towns of Matadi near the mouth of the Congo and La Guairá on the Venezuelan coast, in bleak St. Michael near the mouth of the Yukon and Magallanes (Puntarenas) on the Straits of Magellan, and in dry and dusty Antofagasta and Iquique on the edge of the Atacama Desert. Furthermore, there are hundreds of places with good living conditions that are merely points of transfer, such as Fort William-Port Arthur at the head and Prescott at the foot of Great Lakes navigation which are engaged in the storage and transshipment of grain.

In some cities the commercial and manufacturing influences become difficult or even impossible of accurate discernment. In many cases the commercial city becomes industrial. With superior assembling and distributing facilities and with access to raw materials, the trade center often finds it profitable to engage in manufacture. Thus New York is not only the world's premier port but America's leading manufacturing city. Commerce was the scaffold that started the city and held it up, while a superstructure of manufacturing, finance, and local business was built upon the framework of commerce. Again, political factors sometimes enter into the equation of urban development. The sites of Washington and Canberra, the capitals of the United States and Australia, were arbitrarily determined by law. Neither city has manufacturing worthy of mention, while their commerce is a by-product of the fact that they happen to be the centers of government and the residence of many thousands of federal employees.

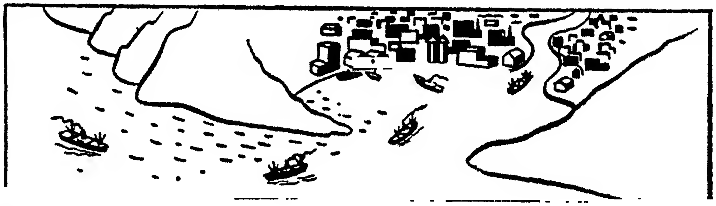
TOWNS ON CARAVAN ROUTES



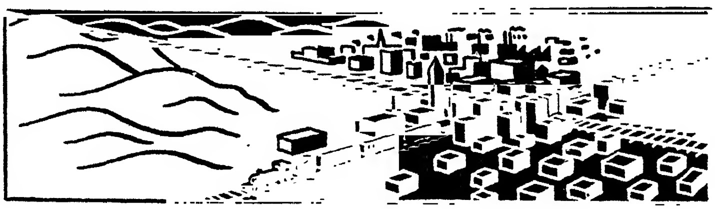
TOWNS ON ROADS



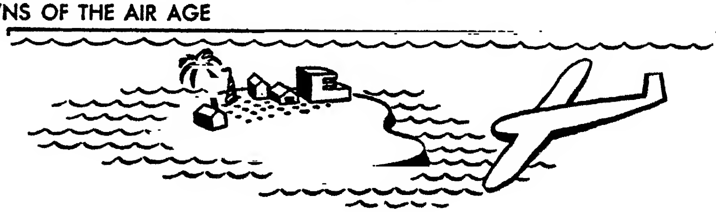
HARBOR TOWNS



RAILROAD TOWNS



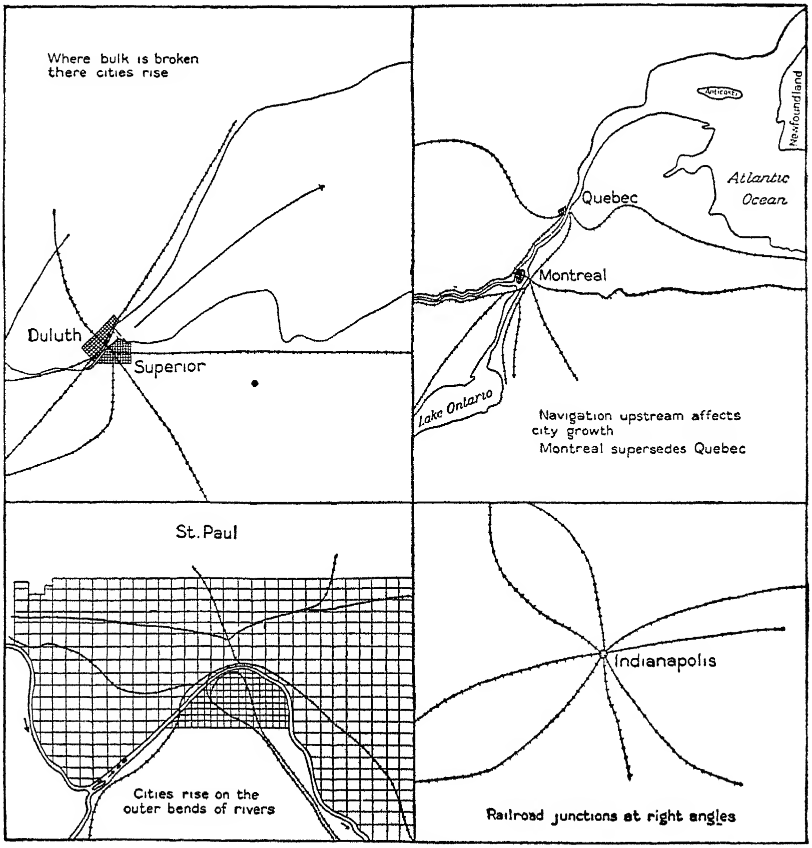
TOWNS OF THE AIR AGE



Pictograph Corporation

But for the smokestack, the caravan town resembles greatly a caravansary in the middle of the Khyber Pass. The road town is good for some of the medieval survivals in Germany. The harbor has too wide a mouth. The town of the Air Age certainly suggests the small amount of freight traffic that the airplane is now competent to carry in this competitive world.

The Place of Transportation in Making Commercial Cities. Some advantage in transportation is the most fundamental and most important of the causes determining the location of a collecting and distributing center.[1] It may almost be said to be the only cause for the formation of such centers. For some reason or reasons, a particular place is more conveniently and cheaply reached by many people than any surrounding point; and, as a result, they naturally exchange commodities there. The country store is located at the crossing of roads. There also is the village. In a mountain country the market town is at the junction of two or, still better, of three valleys. Another favorite location is the end of a mountain pass, or a gap that is a thoroughfare between two valleys. If rivers are difficult to cross, settlements will spring up at the safest ferries or fords. In a level plain, a town will be near its center, and a focus of roads or railroads in such a plain, fertile and populous, will almost surely make a



Trade centers and their classification. These maps explain themselves.

[1] While it is not always possible to determine the exact reasons for the original location of a particular trade center, in most cases it is possible to determine the factors which have contributed to a trade center's survival and growth.—See Eugene Van Cleef, *Trade Centers and Trade Routes,* D. Appleton-Century Co., Inc., New York, 1937, pp. 7-15.

city. Anyone who is familiar with the geography of a peopled area of varied topography can see examples illustrating any or all of these forces.

Prior to the coming of the railroad, inland commerce followed the rivers and the lakes. River ports were rivals of seaports, for the navigable river gave its valley cheap access to the sea. Towns and cities developed at or near the mouths of rivers, at or near the junction of navigable streams, on the outer side of conspicuous river bends where the channel was deeper and a larger trade territory was to be served, at points where transshipment of goods was necessary between deep-draft and shallow-draft steamers, and at the absolute head of navigation. With the coming of the railroad, towns and cities developed beyond the realm of the waterway at points where urban development was previously impossible. On the other hand, the commerce of many a trade center declined as a result of shifting conditions of transportation and trade. Thus, in George Washington's time ships were small, and Alexandria on the Potomac had a prosperous trade,[2] but today Alexandria is merely a residential annex of our capital city, while the trade of Virginia and Maryland flows through the seaports of Norfolk and Baltimore. The railroad train has rushed past the river port to the seaport, and the big ocean steamer has taken the trade.

2. *Seaports and Their Hinterlands*

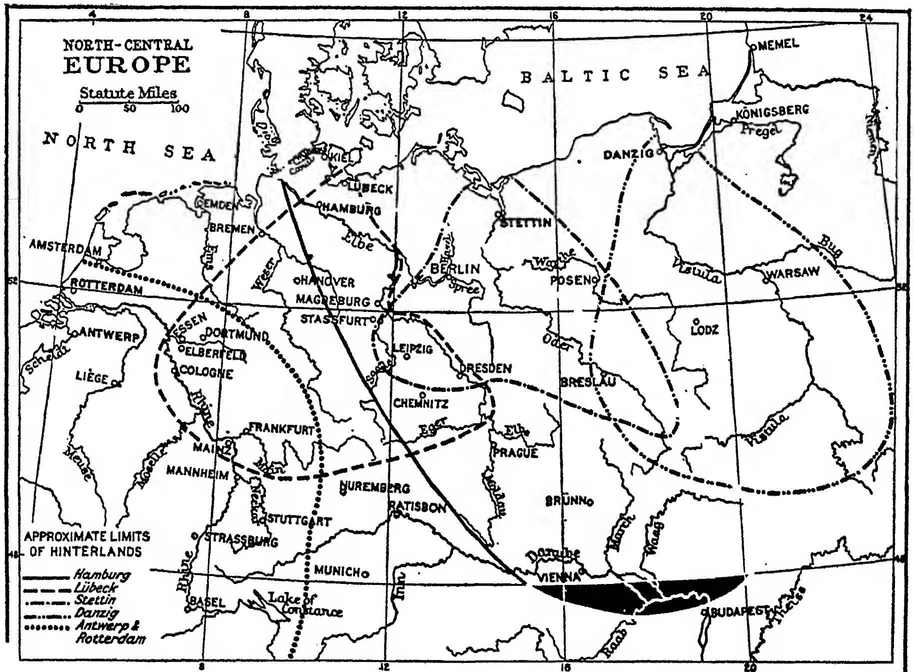
What Makes a Port? A seaport is a gateway between two transportation realms. On the one hand is the sea with its trackless waste offering the cheapest routes for commerce with all the world. On the other hand is the land with its railroads, inland waterways, and highways carrying the commodities of trade to and from the port very much as the blood is carried to and from the heart in our vascular systems. All seaports, therefore, are the focusing points of the commerce of land and sea, bulk-breaking points where the mode of transportation changes. Like all trade centers, the seaport is a collecting and distributing center. Here cargoes are assembled for outgoing ships just as the country elevator collects the wheat of many producers for shipment by rail. Here the incoming vessel discharges its freight, which is taken forward to its destination by smaller and more expensive carrying agents—the coasting vessel, the river boat, the railroad, the motor truck, to some extent the wagon, and, in some countries, even the pack train, and the human carrier of packs. The great seaport exists because it is a place for the breaking of cargo of ocean ships, just as the country store exists because the boxes and cartons of miscellaneous supplies must there be divided up into

[2] The Chesapeake country contains an interesting record of shifts of population centers and trade activity due to changing transport. In Colonial times it was not uncommon for the big planter to own his own sailing vessel and to market his own tobacco in Europe. At this time, sailing vessels came and went from almost any small town along a dozen tidal arms of the Chesapeake. Then the railroad went down the middle of the peninsula between the bay and the ocean. Towns grew up around its stations. It carried more and more of the freight. Then came the cement road and the truck and the railway traffic shriveled, the service dwindled, and people are now building houses along the master truck roads, while many a wharf has rotted, and bushes have grown in many a road which was busy with carts going down to the boat landing a hundred years ago.

numerous small packages for the individual consumer.

Why do some ports flourish while others languish? Among the many factors that determine the prosperity of a port, four factors are of outstanding importance: (1) the size and productivity of the hinterland, or the area that is commercially tributary to the port, (2) the ease of access to the hinterland, (3) the suitability of the harbor site, and (4) the efficiency of terminal facilities. While efficient terminal facilities and a good harbor are great assets to the development of a port, no amount of mere harbor convenience will originate or foster the growth of a port if traffic is lacking. Man can build a harbor, he can set up the facilities for handling cargo, he sometimes overcomes great difficulties so that the port may serve a larger area, but only nature can create the hinterland.

The Hinterland. The volume and kind of commerce transacted in a seaport is fundamentally dependent upon the size and productivity of the hinterland.[3] For example, Bergen, Norway, has little commerce, except fish from the sea, because it is hemmed in by mountains and its restricted hinterland has little production except forestry. In con-



George Philip & Son, Limited

This map shows how some European hinterlands were bounded before World War II. It shows how Rotterdam and Antwerp are dependent for a large part of their commercial prosperity on what goes on in the Rhine Valley, including, of course, the Ruhr.

[3] One of the geographer's most difficult problems is to determine the boundaries of the area that is commercially tributary to a port.—See Arthur J. Sargent, *Seaports and Hinterlands*, Adam and Charles Black, London, 1938.

trast, Houston, Tex., serves a large, level, and productive hinterland that gives rise to a large export of petroleum, cotton, and wheat. Not only do hinterlands vary in size, but the hinterlands of competing ports usually overlap. Thus, the interior plains of North America are tributary to many ports scattered from the St. Lawrence River to the Gulf of Mexico and the Pacific coast. While New York surpasses all of these ports in total volume and value of trade, particularly manufactures, Montreal is the leading grain port, Norfolk and Baltimore handle most of the coal export trade, Houston and New Orleans lead in cotton shipments, and so on. Finally, it should be emphasized that the area served by a port is subject to change, its boundaries advancing or receding in response to changes in tariff duties and inland transportation facilities and rates, the availability of steamship services, the adequacy of terminal facilities, the initiative of exporters and importers, and other variable factors.

The productivity of the hinterland is determined by its natural and human resources, and productivity is more important than size. For example, Tripoli and Calcutta both serve large hinterlands, but the former lies on the edge of the Sahara Desert, while the latter is the gateway of the fertile and populous Ganges Valley. Rotterdam and Antwerp serve smaller areas than New Orleans, but their commerce is far greater, whether it be measured in terms of value, weight, or the number and capacity of ships that enter and leave during the course of a year. Furthermore, some hinterlands offer a variety of products for export, while others yield only a single commodity. Thus, Buenos Aires ships large quantities of wheat, corn, flax, meat, wool, quebracho, and other products, while Iquique exports only nitrate. Fortunate is the port that lies in the midst of a populous and productive area providing both a great market for imports and a large and varied supply of exports.

Access to the Hinterland. Unless the resources of a hinterland are accessible, they remain potential rather than actual bases of trade. Cheap and easy access to the hinterland is largely a matter of location and transportation. An inland location on a deep arm of the sea is good, for ocean vessels can travel farther inland, giving the exporter and importer the maximum advantage of low ocean freight rates. Therefore, the great ports are at the heads of bays, gulfs, and estuaries rather than on peninsulas and headlands. Montreal lies 1,002 miles from the sea on the deep St. Lawrence River, and its interior location makes Montreal a far better port for Canadian trade than Halifax on the Nova Scotian peninsula. The rugged west coast of Great Britain offers many bays and harbors for the shelter of shipping, but none of the small ports on projecting Cornwall displaces Bristol as the leading harbor of the southwest of England, for Bristol is far inland on the head of a bay. In the same way Liverpool, the great port of the west, has grown up on the indented coast of Lancashire, and not on some of the equally safe bays of the projecting coast of Wales. Similarly, Boston and New York are on bays that indent the mainland, not on those more easy of entrance but near the end of Cape Cod or Long Island.

Besides easy access from the sea, the great seaport, the international trade

center, must have easy access to the land and to the centers of population that it serves. This access is best supplied by a river valley with water transportation on the river itself and canals and railroads that can be built most easily along watercourses. Nearly all important seaports are at, or near, the mouths of rivers, navigable or otherwise, and, in regions having navigable rivers, the largest cities are in locations having the best communication with the interior. New Orleans, on the lower Mississippi, has been, from its settlement, the unrivaled metropolis of the coasts of the Gulf of Mexico. Philadelphia, Boston, and Baltimore were the rivals of New York till the opening of the Erie Canal made the Hudson the outlet for the Great Lakes and of enormous territory in the center of the continent. With this advantage New York gained a foreign trade exceeding that of all the other Atlantic ports combined. If the break in the Appalachians had been at the head of the Delaware, the Susquehanna, or the James, the location of our great commercial metropolis would surely have been different. Furthermore, the low-level route of the Erie Canal through the Hudson-Mohawk Depression was the most favorable of all trans-Appalachian routes for the construction of railroads and highways, with the result that New York continued to have easier and cheaper access to the heart of the continent than any of our Atlantic ports.

As in America, so in other continents, the navigable river has dominated the growth of seaports. It is not by accident that London and Liverpool are upon the Thames and the Mersey, respectively, with their canal and railway connections with the interior. Hamburg has outstripped Bremen because the Elbe is navigable even beyond the Czechoslovakian boundary, but the Weser gives Bremen only inferior communication with the interior. The Nile has made Alexandria; the Ganges, Calcutta; the Yangtze, Shanghai; and Canton and Hongkong, the outlets for the trade of southern China, lie near the mouths of the Si, Tung, and Pei rivers.

The Harbor. Some ports have splendid natural harbors; others have artificial harbors built at great expense; while some ports have no harbors at all, vessels being loaded and unloaded with the aid of barges and lighters in an open roadstead. No harbor is perfect in every respect, but the more it approaches the ideal, the better it serves the needs of shipping and trade. The advantages of an ideal harbor, with brief comments, may be enumerated as follows:

1. Protection from winds and waves. Without such protection, a ship must weigh anchor in times of storm and seek the comparative safety of the open sea. Many a port has built a breakwater of concrete or stone to obtain such protection, e.g., Madras, the chief port on the harborless east coast of peninsular India. A few inland cities have dug out a basin and connected it with the sea by canal, e.g., Houston, Tex., and Manchester, England.

2. Deep water in the channel and close to shore, not exceeding 100 feet. New York has 40 to 45 feet of water in its main channels, which are kept clean by tidal scour and some dredging and which accommodate the largest of ocean liners. Rotterdam, Antwerp, Shanghai, and most river ports must spend money on constant dredging. London, Hamburg, and Bremen had to build sub-ports nearer the sea to handle the big ships of today.

3. Abundant anchorage space. Superliners like the *Queen Elizabeth* require a radius of half a mile to turn around. Few harbors are as commodious as New York, Hampton Roads, and Rio de Janeiro, each of which could hold the ocean-going merchant vessels of the entire world.

4. A harbor entrance that is wide, straight, and deep. Many ports lack this advantage, and congestion, delay, and high pilotage charges are often the result.

5. A tidal range of less than 15 feet so that ships may load and unload at all stages of the tide. At New York the tidal range is 4½ feet; at Baltimore, only 1 foot; at Liverpool and Le Havre, 25 to 30 feet. Many ports of western Europe had to build tidal basins equipped with locks, ships entering and leaving only at high tide.

6. Freedom from ice. Sometimes powerful ice-breakers can be used to maintain an open channel. Such ports as Montreal, Archangel, various Baltic ports, and Vladivostok lose trade when navigation is closed by ice.

7. Freedom from fog. New York has 1,064 hours of fog per year, or an average of 2.91 hours per day. In spite of the use of bells, whistles, radio, and other devices, shipping sometimes comes to a dead halt, resulting in a costly loss of time.

8. Ample room for wharves, transit sheds, warehouses, belt-line railroads, and other terminal facilities. Such fiord harbors as Bergen, Norway, where precipitous slopes adjoin the waterfront, have almost no room at all. Seattle had to excavate a hill to provide room for buildings. On New York's crowded Manhattan Island waterfront space is limited and expensive.

Terminal Facilities. Human labor is commonly used for loading and unloading cargoes in many Oriental ports, where labor is cheaper than machinery, but modern ports have elaborate and expensive terminal equipment. Vast sums of money have been invested in wharves; cranes, derricks, conveyor belts, and other mechanical facilities for handling freight; transit sheds and warehouses for the protection and storage of freight; and belt-line railroads, barges, lighters, and motor trucks for the local assembly and distribution of cargoes. The port of New York has about 2,000 piers and quays along its 650 miles of improved waterfront.[4] In contrast, the ports of London, Liverpool, Hamburg, Bremen, Amsterdam, Rotterdam, and Antwerp all together do not occupy half as much space as the port of New York. Each of these European ports has a harbor that is little more than a hole dug out of the mud, yet at times each has handled nearly as much traffic as New York. It is all-around port efficiency rather than the length of the waterfront that counts. Several European ports handle three to four times more cargo per linear foot of wharfage than New York. Hence, New York's slogan, "Biggest in the World," must be taken for what it is worth.

Whether or not it pays to mechanize terminal facilities depends upon the nature of the cargo to be handled, the volume of traffic, and the prevailing wage rates of labor. Some commodities by their nature are handled more easily than others. The easiest cargoes to handle are such bulk commodities as oil, grain, ore, and coal, which are not injured by rough handling. These are usually shipped in full cargo lots and can be handled by specialized equipment. Thus, petroleum is pumped into and out of tankers with great dispatch,

[4] For a well-illustrated account of the advantages of the port of New York, see Port of New York Authority, *The Port of New York*, New York, 1941.

while grain pours into tramp steamers from elevator spouts and is unloaded by powerful pneumatic suction pipes. Standard package freight is also easily handled by specialized machinery, because each unit of freight is of identical size, shape, and weight, such as bales of cotton, bags of coffee, bunches of bananas, bags of sugar, barrels of apples, and frozen carcasses of meat. For example, portable tiering machines place barrels of apples one above another. Bags of coffee move across the wharf and over the ship's side on conveyor belts and then are lowered into the cargo hold by a rope sling, a huge basket of strong rope that is suspended from one of the ship's cargo booms. The most difficult cargo to handle is general cargo, or miscellaneous freight consisting of odd-sized boxes, crates, and packages of manufactured goods and other commodities. At modern ports hand trucks, electric trucks run with storage batteries, and portable conveyor belts are used to assemble parcels of freight alongside the ship, but the strong backs of longshoremen are frequently indispensable. If the cargo consists of locomotives or other items too heavy for the ship's tackle or existing terminal facilities, powerful hoists will have to be installed to do the job.

The modern ship is a titanic mechanism requiring great care and many supplies and services. The larger seaports are able to provide fuel, water for boilers and drinking purposes, food, miscellaneous ship's stores, dunnage or loose stuff for the stowage of general cargo, disinfection and medical service, ship classification and inspection, minor repairs, dry dock service, financial assistance, and officers and crews.

The waterfront is a busy place with many functions to perform, and Europeans have long recognized that it is vested with a public interest. In Europe most ports are either owned and operated by the government or by a board of impartial, non-salaried representatives of the municipality and the commercial interests of the port. In the United States most of the best waterfront space long ago was taken over by the railroads and other big corporations for private use and private gain.[5] As a consequence, local industries have often been forced to use inferior locations along the waterfront, and in some cases steamship lines have been excluded from a port because wharfage space and other facilities were under the control of rival companies. Indeed, the crowded waterfront is the weakest link in the American transportation system today.

Types of Ports. One of the changes in the world commerce of the past has been the pronounced separation of ports into classes. On the basis of traffic, ports may be divided into two groups, passenger ports and freight ports, while the latter may be subdivided into two major classes, raw-material ports and manufactured-goods or general cargo ports. Only a few ports have a predominantly passenger traffic. Such ports are Southampton and Plymouth in southern England where passengers, mail, and express are unloaded from great trans-

[5] New Orleans and San Francisco are public ports; Seattle, Portland, and Gray's Harbor are partially administered by port authorities similar to the public trust ports of London and Liverpool; New York and a few other ports are semi-public ports; but most American ports are under private ownership and management.—See Abraham Berglund, *Ocean Transportation*, Longmans, Green & Co., New York, 1931, pp. 133-134, 145-149.

Atlantic liners and are rushed to London on special non-stop trains. Likewise, in France passengers disembark at Cherbourg, and to a lesser extent at Le Havre, and hasten by fast trains to Paris. In Argentina combination passenger and cargo liners often call first at the port of La Plata, passengers taking the train to Buenos Aires while the ship proceeds slowly through crowded waters to its wharf in Buenos Aires about 40 miles upstream. Because of location, such ports are able to facilitate the inbound and outbound movement of passengers, mail, and express, such traffic requiring rapid transportation.

Raw-material ports today are far more numerous than manufactured-goods ports, and the two classes are steadily growing more distinct at the present time. This has resulted from the vast multiplication of the bulk of commerce —a multiplication which is in turn the result of the numerous industrial changes brought about during the past hundred years by the application of steam and electricity to so many of man's activities. The commodities have changed from the small-bulk and high-value goods such as tea, silk, furs, spices, and luxury goods to the cheap and bulky raw materials—grain, lumber, coal, petroleum, ore, and the coarser fibers. Spices, for which India was once so important, have dropped from tenth to forty-second place among her exports between 1911 and 1939, although the world consumes more spices than ever before.

The filling of the channels of trade with the many bulky, cheap, or perishable articles has produced new trade conditions with less dependence upon great ports and distribution centers. In order to avoid the expense of long rail hauls, cheap and bulky commodities generally seek the nearest port of exit, and they are shipped to best advantage in full cargo lots. Since the vessel takes no other freight, it can load at any small port near the place of production. It is easy and profitable for a vessel to go to a small port of Florida or Georgia for a full cargo of phosphate or lumber, to a Chilean outport for nitrate of soda, to a West Indian outport for iron or bananas, to Cardiff, Wales, for coal, to a Philippine port for copra, or to a small Texan port for wheat. These goods may sometimes be imported by a small port for use in local industries that do not require a large population for the manufacture and distribution of the products. A railway, a pier, and suitable warehouses may enable a small town to export or import raw material in bulk. Many of the world's great raw-material ports, therefore, are small places. In contrast to this, only a large city can import or export cargoes of highly manufactured goods. These articles are consumed in much smaller quantities than raw materials. Much choice is exercised in their selection and purchase by the consumer. The retail dealer must exercise similar care and discretion in the selection of his stock. He can do this best in a great wholesale market where he can go from place to place and take advantage of the competition and variety of stock of many wholesale merchants. This is to be found only in a great city. This gives the city holding the trade in manufactured goods the conservative force that comes of its being known as a market. The trade in manufactured goods, therefore, continues to

cling to the older distributing centers and devious routings long after it is possible to make direct shipments.

The nineteenth-century development has been not so much a revolution as a new growth. The old commerce of 1800, the trade in high-value goods, stays, much augmented, in the old centers; and the new commerce in bulky raw materials goes to them and also directly between small ports. This gives to the trade of almost all ports a one-sided characteristic which has a profound influence upon the ocean-carrying trade.

Lack of balance in freight movement means:

More ships needed to carry the world's trade.

Where liner service is established, much ship space in ballast.

The need of a fluid supply of tramp ships needed because of ill balance of cargo tonnage, especially if movement of cargo is seasonal.

Higher freight rates.

The greater number of the world's ports are either importing or exporting ports, and it is unusual for a port to have an equal share of imports and exports.

Nearly two-thirds of the imports of the United States, whether measured in terms of value or weight, enter the country through the long-established ports of New York, Boston, Philadelphia, and Baltimore. These four ports

TABLE 44

CARGO TONNAGE OF PRINCIPAL AMERICAN SEAPORTS, 1940 *

(In thousands of short tons)

Port	*Total*	*Imports*	*Exports*	*Coastwise*	
				Receipts	*Shipments*
New York	65,423	12,835	10,413	33,821	8,354
Philadelphia	31,065	5,779	2,269	18,263	4,754
Hampton Roads	26,900	966	4,015	2,939	18,980
Houston, Tex.	23,679	1,458	2,968	1,761	17,492
San Francisco Bay	22,560	695	2,947	12,891	6,027
Los Angeles	18,787	569	5,055	5,009	8,154
Beaumont, Tex.	17,771	77	786	962	15,946
Boston	17,492	2,281	455	13,132	1,624
Baltimore	17,364	5,981	3,498	5,833	2,052
Port Arthur, Tex.	17,318	36	2,045	1,088	14,149
Puget Sound †	12,816	1,369	1,175	5,821	4,451
New Orleans	11,614	2,896	3,351	1,812	3,555
Texas City, Tex.	9,758	86	709	1,072	7,891

* All data exclude purely local harbor traffic and commerce with ports on internal rivers or canals. All coastwise traffic is restricted by law to ships flying the American flag.

† Of Puget Sound traffic, Seattle's total tonnage was 5,536, including imports 301, exports 486, coastwise receipts 3,002, coastwise shipments 1,747.

lie adjacent to the greatest centers of population and manufacture, and are the cities with the oldest and best ocean connections. Likewise, San Francisco, the old gateway for Oriental imports, is our leading port of entry on the Pacific coast. In contrast, the new ports of Texas are distinctly raw-material ports, with a heavy excess of outbound traffic (see Table 44).

In exporting manufactured goods there is the same tendency to cling to the old and great port, although the tendency is here weaker than it is in the importing of similar goods. The conservative force is the fact that manufactures usually go in small shipments of which many are required to fill a single ship. Add to this the fact that the shipper of goods of this class wishes as fast, frequent, and wide-reaching sailings as possible, and it is evident that he can only get what he needs by doing business through the largest accessible port.

TABLE 45

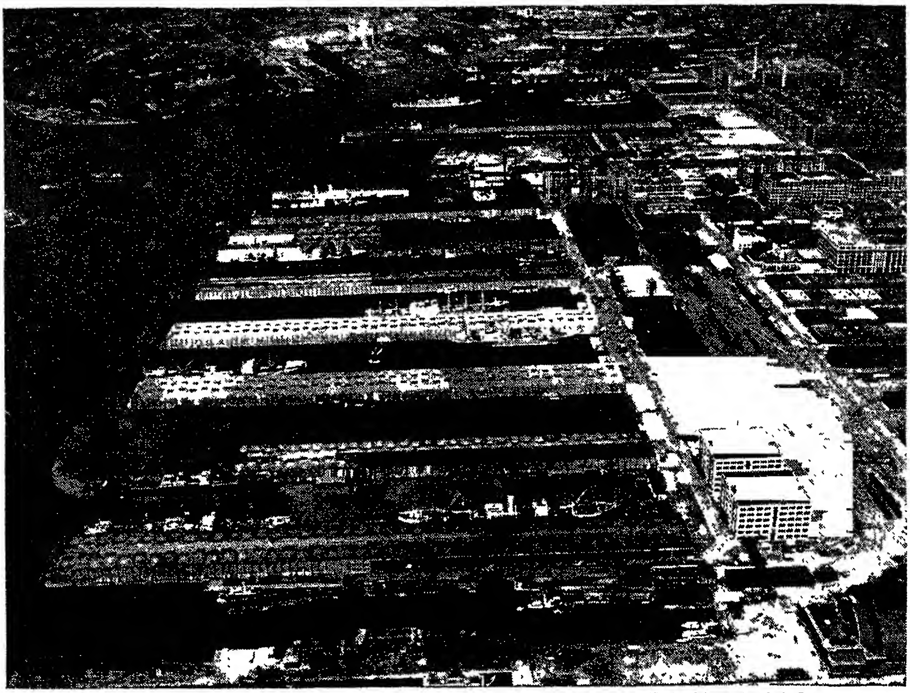
TONNAGE ENTERING 50 GREATEST PORTS OF THE WORLD, 1935

Rank	*Port*	*Vessels*	*Net Register*	*Rank*	*Port*	*Vessels*	*Net Register*
		No.	Tons			No.	Tons
1	New York (Upper Bay)	92,032	68,598,000	26	Vancouver, Canada	16,970	11,488,000
2	London	29,137	29,673,000	27	Rio de Janeiro	3,924	11,226,000
3	Kobe	26,776	28,334,000	28	Genoa	5,421	10,860,000
4	Yokohama	5,757	26,785,000	29	Naples	9,008	10,809,000
5	Rotterdam	110,406	22,415,000	30	Houston	7,275	10,091,000
6	Baltimore	56,067	21,008,000	31	Sydney, Australia	6,855	10,057,000
7	Colombo	2,708	20,425,000	32	Newcastle (England)	8,532	8,596,000
8	Osaka	18,999	19,600,000	33	Montreal	5,725	8,516,000
9	Antwerp	11,125	18,730,000	34	Bremen	7,118	8,300,000
10	Hamburg	16,141	18,418,000	35	Seattle	3,416	8,210,000
11	Philadelphia	8,302	17,907,000	36	Montevideo	1,631	8,087,000
12	Shanghai	8,488	17,418,000	37	Piraeus	13,396	7,758,000
13	Los Angeles	5,369	17,211,000	38	Melbourne	3,396	7,613,000
14	Liverpool	14,614	16,640,000	39	Copenhagen	25,432	7,452,000
15	Marseille	9,135	16,612,000	40	Portland, Ore.	9,548	7,051,000
16	Hongkong	5,947	15,340,000	41	Bombay	33,731	6,547,000
17	Boston	7,340	14,978,000	42	Cherbourg	952	6,478,000
18	San Francisco	17,353	14,974,000	43	Capetown	1,629	5,454,000
19	Singapore	5,934	14,800,000	44	Galveston	1,762	5,383,000
20	Buenos Aires	14,826	13,435,000	45	Batavia	2,183	5,338,000
21	New Orleans	16,287	13,319,000	46	Jacksonville	1,810	4,523,000
22	Duluth Superior	2,807	12,882,000	47	Savannah	1,395	4,075,000
23	Southampton	15,628	12,509,000	48	Calcutta	1,296	4,059,000
24	Norfolk	7,089	12,222,000	49	Curaçao	5,047	3,700,000
25	Havre	9,018	11,572,000	50	Charleston, S. C.	10,668	3,226,000

The data cover entrances in 1935; there are no later figures.

The Houston Ship Channel, an inland waterway, 50 miles from the Gulf of Mexico, was used in 1939 for the transportation of 28,156,747 short tons of cargo.

Ports of call for passenger steamers look bigger than their trade is—Southampton, Cherbourg, Hongkong.



Fairchild Aerial Surveys, Inc.

The Bush Terminal in Brooklyn, New York, gives us an inkling of what capital and planning can do for industry and commerce. If you wish to manufacture something in a small way, you may perhaps rent some machinery, move it into a few leased rooms in one of the white buildings at the lower right. The elevator will bring your raw material from the truck in the street at the left or from the freight car on the switch at the right. You may plug in your wires, draw current from the wall, and start your machinery. If you wish storage space, you may rent it in any one of the long row of warehouse buildings on the same street as the two white factory buildings.

If you wish larger manufacturing space there are several blocks of other factory buildings at the upper right. Those belonging to the Bush Terminal Company, which are for rent, go as far as the white smokestack, which is on the Navy building for the manufacture of clothing. At the left, a row of docks and piers covered by freight sheds. Ships come from the end of the world to load and unload. You can see two steamers lying beside the first freight shed. On the near side of the same shed are several car floats, bringing cars from railroad terminals of any one of many railroads that reach New York harbor. These floats probably make New York harbor the greatest car shifting yard in the world.

The stupendous size of all this is shown by the diminutive appearance of freight cars as they stand in the freight yard at the lower right. This freight yard and two miles of railroad along the water front are a part of the Bush Terminal enterprise.

The freight sheds on the piers may receive a cargo from one ship to be loaded on freight cars for shipment by land, loaded on trucks for distribution somewhere in New York City, to be sent to the factory buildings above mentioned, to be sent to the warehouses across the street, or put on another ship for coastwise distribution or to go to another continent. It may reach the other ship by being put in a barge, taken a few miles up the East River or the Hudson or across the Hudson to Hoboken or over to the Newark harbor.

New York harbor is in two states, but it is operated by one harbor authority, a comparatively new kind of government which we are rather rapidly developing in this country—Tennessee Valley Authority, Missouri Valley Authority(?).

There are many disadvantages of the great city as a place for human beings to live, but this Bush Terminal typifies the many advantages that the great city has for industry.

Manufactured-goods ports, therefore, require the fast and regular service of ocean liners, while raw-material ports often depend upon the slower but cheaper transportation afforded by tramp ships.

Great Britain is far more dependent upon the import of raw materials and foodstuffs and the export of manufactures than the United States. Both the value and weight of British imports are greater than exports, a reversal of commercial conditions in this country. While Cardiff and Newcastle are great exporters of coal, most British ports import much more than they export. On the basis of value, nearly two-thirds of all British imports and one-half of the exports are handled by London and Liverpool.

New York: The World's Premier Port. Of all the world's cities, New York is the most gigantic product of transportation. Nowhere else in the world is there such a supreme focus of routes by land and sea. None of the world's seaports equals New York in the total value of its foreign commerce.[6] Each year the total net tonnage of vessels entering and clearing the port of New York is more than double that of London, its nearest rival. For the last 20 years about half of all our imports and more than a third of our exports, on the basis of value, have moved through the port of New York. In terms of cargo tonnage, it ranks first among American seaports in volume of imports, exports, and receipts of coastwise cargo, but its outbound movement of coastwise cargo is surpassed by that of several of our raw-material ports (see Table 44). New York is North America's greatest gateway for the inflow and outflow of manufactures, which loom high in value, but that is not all. Inbound vessels bring large quantities of petroleum, coal, coffee, raw sugar, crude rubber, wood pulp, tin pigs and bars, cacao, bananas, vegetable oils, jute, cotton, wool, and lumber, while outbound vessels carry scrap iron and steel, wheat, leaf tobacco, apples, and many other commodities.[7]

It was not by accident that New York has become the world's greatest seaport and an international trade center of the first magnitude. The city is centrally located in a densely populated, wealthy, industrial and commercial area along our northeastern seaboard. It faces Europe, our greatest market for exports and a leading source of imports. Its immediate hinterland is both a great producer and consumer of goods. Farther inland lies the continental interior, a tributary hinterland that is unrivaled in size, productivity, and purchasing power. To this peerless hinterland, New York has long had cheap and easy access. To the outside world, it has more regular steamship services than any port in the Western Hemisphere.[8] At its doorstep the drowned valley of the Hudson provides one of the world's best

[6] The value of merchandise imports and exports fluctuates sharply with business conditions at home and abroad. Total value of New York's foreign trade in billions of dollars: 1920, 6.2; 1922, 2.9; 1929, 4.1; 1932, 1.0; 1940, 3.1. The tonnage of exports and imports also fluctuates but not so precipitously as values.

[7] Of the total tonnage of cargo moving through American seaports, New York normally handles more than one-third of both imports and coastwise receipts and more than one-fifth of exports and coastwise shipments.

[8] Prior to the outbreak of World War II, steamship lines provided 126 direct sailings monthly from New York to European ports (British Isles, 31; Rotterdam-Antwerp, 29; Baltic, 21; Mediterranean, 18; Hamburg-Bremen, 14; western France, 9; Spain-Portugal, 4), 5 monthly sailings to India via the Red Sea, 4 to West Africa, 12 to South and East Africa, 32 to the Far East, 4 to Austral-

harbors. Its terminal facilities include some of the most modern equipment in use today. Its exporters and importers are more aggressive than ever before, and capital is easily available for the financing of foreign trade. New York today is the world's greatest financial center and a great market place where business transactions occur daily that affect the lives of men throughout the world.

3. *The Entrepôt Center*

The Nature of Entrepôt Trade. In addition to ordinary incoming and outgoing trade,[9] some ports are engaged in the distribution of foreign goods to foreign countries. Such re-export or intermediary trade is known as entrepôt trade. Thus, London has long had a large commerce in goods that do not originate in Great Britain and are not intended for distribution in Great Britain. Likewise, the island of Hongkong is an entrepôt center for the trade of southern China, this center having been established by the British in 1842 at a time when Chinese ports were closed to foreigners. Prior to World War I, the island of Zanzibar was an important entrepôt center for the east coast of Africa, vessels calling at the island to leave goods for later distribution along the coast and to pick up cargoes that had been previously assembled by small coastal ships. The entrepôt center, therefore, is interposed between a producing and a consuming country just as in domestic trade a middleman stands between producer and user.

The commodities that are best adapted to the entrepôt method of distribution are non-perishable goods that are of high value in proportion to their bulk and weight. This intermediary, or distributing trade, national or international, is the second step in the development of a city. The first step is the establishment of many lines of transportation giving connection with the various countries engaging in international trade. These are only built up by local demand and local production.

The chief reason for the growth and prosperity of London was not her foreign distributing trade, but the commerce that came to her as the local center of a great industrial population and the commercial capital of the country where the most highly developed manufactures in the world fostered the largest import and export trade. The chief basis of a city's trade under modern commercial conditions is usually to be found in the industrial districts of which that city is the immediate distributor, and not in the business that comes to a city as a commercial intermediary. By having high value the freight rate is relatively insignificant, and the long and devious journeys are not a serious handicap. Having small bulk there is not the demand for a whole shipload of them in any one place, and so it is really cheaper to let them wend their way by transshipments through the common distributing center or entrepôt. A sec-

asia, 28 to the east coast of South America and 8 to the west coast, 120 to the Caribbean, 20 to to eastern Canada, 150 to the east coast of the United States and 25 to the west coast.—Port of New York Authority, *op. cit.*, p. 29.

[9] The ordinary traffic of a seaport may be divided into two classes: (1) local traffic, consisting of outbound cargo that originates within the port and inbound cargo that is destined for the port, and (2) through traffic, or cargo that originates within or is destined for the hinterland.

ond factor of influence is the question of distance. The more remote the origin and destinations of the traffic the stronger is the hold upon this trade of the entrepôt with its organization of routes, ready to serve and hard to duplicate.

Entrepôt Trade of the Past. For centuries prior to the Industrial Revolution, world commerce was predominantly a trade in luxuries and exotics. In this trade the entrepôt center played a major role. An outstanding and very profitable branch of commerce consisted of the exchange of goods between the Orient and Europe. From the Orient came spices, silk, tea, drugs, perfumes, embroideries, velvets, satins, fine cotton goods, curios, and precious stones—goods of small bulk and very high value. In return, Europe was able to ship some raw wool, hides, woolen goods, and common linen, but she had to pay for most of her Oriental imports with gold and silver. These commodities were shipped in small lots and could be easily handled by camel caravans on the long overland routes across Asia and by the small sailing vessels of those days. Oriental products were consumed throughout western Europe, but always in small quantities. They were produced in a remote part of the world, and it was commercial economy that they should be distributed among western countries from some western entrepôt. The city best fitted to render this distributing service was the one where varied industry had given the most widespread vessel connections. The shifting of this trade from route to route and from center to center is an interesting study of commerce as affected by war, politics, discovery, invention, geographic control, and the economic conditions that resulted from these forces. During the ordered period of the Roman Empire this unimpeded commerce was divided among many cities. After the fall of the Empire in the West, Constantinople, the seat of the strongest European power, became the richest commercial city of Europe and one of the important gateways to the East. Following the decline of the Byzantine Empire one city or another controlled a large share or even had a monopoly of the valuable commerce that passed between eastern Asia and western Europe, and each became an object of envy for the trading world.

For years Venice monopolized the trade with the Orient, but after Vasco da Gama's discovery of a sea route to India via the Cape of Good Hope, commercial supremacy passed to Lisbon and in turn to Bruges, Antwerp, Amsterdam, and London. Amsterdam's monopoly was less complete than that of her predecessors, and the predominance of London was never so complete as that of Amsterdam.

London: The World's Greatest Entrepôt Center. From the middle of the eighteenth century until the present day, London has remained the greatest of all entrepôt centers. London's supremacy was the heritage of Britain's quest for empire. As a result of long but victorious wars with Spain, Holland, and France, Great Britain emerged as the world's greatest commercial nation served by the most powerful navy and the largest merchant marine, and London became the world's greatest financial and trading center. With the growth of the British Empire, increasing quantities of colonial products came

to London for local consumption and for redistribution to Europe. With the coming of the Industrial Revolution and with the development of many new countries overseas, both the direct and re-export trade increased tremendously. With the development of steamships and railroads, the luxuries and exotics of former years declined in price and no longer dominated the entrepôt trade. In 1938 Great Britain's leading re-exports were wool, hides and skins, tea, copper ingots and bars, and crude rubber. These five products, worth $165,000,000, accounted for one-half of the total value of British re-exports.

The entrepôt trade of Great Britain has been marked by a number of long-run changes. At all times the entrepôt trade has been subsidiary to trade that was essentially local in its origin or destination, but the relative importance of entrepôt trade has been steadily declining. In 1936-38 goods destined for re-export accounted for only 12% of total imports, as compared with about 20% from 1870 to 1900. Secondly, the entrepôt trade has come to include a much greater variety of products. Of the articles that dominated the trade in 1800, only tea remains of outstanding importance, and it is no longer a luxury. Thirdly, London and Liverpool are faced with increasing competition from Hamburg, Rotterdam, Amsterdam, and Copenhagen in the distribution of overseas products destined for the countries of western Europe, while New York now imports directly from producing countries many commodities that were once shipped through Great Britain, such as tea, silk, rubber, jute, Egyptian cotton, wool, coffee, and cacao. Hence, the relative importance of London among the world's entrepôt centers has declined. That London still ranks first shows the advantage of her location, her shipping conditions, the reluctance of traders to change their habits, and the tremendous power of the world-wide contacts of British importing firms, banks, and shipping companies. In spite of the fact that other entrepôt centers are developing, it is unlikely that London will be displaced by any single successor.

Decline of the World Entrepôt Center. While it is probably true that the total value of entrepôt trade throughout the world is greater than ever before, the relative importance of re-export trade is steadily declining. The pre-eminence of the world entrepôt center is on the wane largely because of two developments. First, the tremendous increase in the bulk of world commerce. The second grows out of the first and is the multiplication of steamship and railway lines which enables many cities to serve as entrepôts for limited areas.

On the question of the supremacy of commercial cities, the future cannot be judged by the past. The mechanical improvements of modern times have made a new industrial and a new commercial world which must be judged by the new conditions.

The great inventions of the present era have increased manyfold the materials of commerce. These changes have permitted a rapid increase in population in commercial countries and have brought about the settlement of new continents. Wildernesses in North and South America, Australia, and Africa have become the homes of people having wide commercial relations. Where an occasional trading ship loaded with

valuables and trinkets made a bartering cruise in 1800, fleets of steamers assembled in 1900 to carry away the coarse bulky staples of international trade; and, in the first decade of the twentieth century, the progress in this direction was more rapid than ever. No city could handle it all if she tried; but, nevertheless, Great Britain, especially London, had a strong hold during the greater part of the nineteenth century.

Other Nations Rise to Commercial Independence. When Germany, Denmark, France, Belgium, or the United States wanted small shipments of Indian or Oriental goods, it was convenient and financially advantageous to get these goods in Great Britain, because Germany, Denmark, France, Belgium, and the United States had regular and frequent connections with Great Britain, which had good connections with the Orient. After a century of multiplication of commerce, London is still the leader, and richer than ever; but other cities are also distributing the products of the East since they have developed direct connections of their own. Half a dozen British ports have direct lines to the East. In 1939, German lines went from Hamburg and Bremen, French lines from Le Havre and Marseilles. There are frequent and regular eastern sailings from Antwerp and Genoa, and at less frequent intervals from Copenhagen. New York also has regular connection with the Orient, Australia, Africa, the coasts of South America, and the ports of the Mediterranean and the Baltic.

As Great Britain between 1750 and 1850 established the factory system, built up industrial cities, a foreign trade, and lines of communication, so in the latter part of the nineteenth century the United States and the continental countries of Europe experienced the same industrial revolution and the accompanying growth of cities and of industries. The last and inevitable step in the chain of events has been the establishment of direct communications between the Orient and other ends of the earth to give an outlet and supply for these new-grown centers of industry. The increase of direct connection and the growing complexity of the international trade route net is a pronounced and characteristic tendency of the later decades of the nineteenth century and of the present. Great Britain retains her position of independence, but in 1939 other countries—the United States, Germany, Belgium, Italy, France, and Japan—were advancing toward a similar independence. There is a consequent tendency for each country to raise up its own entrepôt. We can indeed see the progress before our own eyes, for the centrifugal or decentralizing forces continue.

Other Cities Become Entrepôts. Before World War I Hamburg had, in large degree, succeeded London and Liverpool as the basis of foreign goods supply for Scandinavia and the Baltic; but almost before Hamburg was secure in her new trade possession, lines of steamers were beginning to carry the products of America and the Orient direct to Stockholm, to Copenhagen, and to the Russian ports. Lines from the United States to Genoa have largely displaced trade via Liverpool, and the more recently established lines from New York to Istanbul (Constantinople) and the Levant are cutting off the trade to the United States via Genoa and Mar-

seilles. An examination of port connections the world over will show the same conditions of decentralization and growing freedom from a few great ports that has taken place in Great Britain and the continent of Europe. Two examples will suffice to show the tendency.

The increasing trade of the ports of north China adjacent to the Gulf of Pohai (Pechili) makes it profitable for occasional vessels to take cargo direct from America and Europe to ports of Tientsin, Yingkow (Newchwang), and Talienwan. At one time nearly all of the trade of east Asia was first laid down at the great entrepôts of Hongkong, Shanghai, and Yokohama, for final distribution in small craft. As commercial development on this north coast continues and satisfactory harbors are made, there is less and less dependence upon Shanghai, Yokohama, and Hongkong and more direct connection with the remote bases of supply at San Francisco, Seattle, New York, London, Liverpool, Hamburg, and Marseilles.

Another example of this world tendency comes from Australia. For many years the sparse population of Western Australia secured the greater part of its European and American goods by the coasting steamers that came from Sydney and Melbourne. The rich gold discoveries so increased the population and trade that after 1898 the west coast began to receive European steamers direct, and is in large measure freed from its dependence upon the east coast cities as bases of supply for European goods.

Relative Decline and Absolute Increase. It must be kept in mind that decentralization does not destroy the old trade center. The statements concerning declining importance are relative, applying to percentage of rapidly growing wholes, and not in any way to absolute quantities. Commerce has been increasing with unprecedented rapidity, and the new developments, the new trade routes, are made by and for a part of the new commerce. Meanwhile, it is usually true that the particular trade that inevitably belongs to the old center has also increased and, with it, the city's prosperity. It is still a distributing center, greater than ever, but for a smaller territory with increased commercial activity. Antwerp, with a greatly improved harbor, at times handles a larger tonnage of freight than any port in Europe. London's distributing trade has suffered from the competition of Antwerp, Hamburg, Bremen, Marseilles, New York, and other cities; but London has millions more people than she had in 1856 when the first Hamburg trans-oceanic steamship line was established, and she is still struggling to enlarge her harbor. New York handles a smaller and smaller percentage of the foreign trade of the United States, but, as other American cities increase their imports and exports, New York's foreign trade reaches a total greater than that of any other city in the world.

Effect of Grading Goods. The question of international distributing centers is not alone affected by routes of transportation and the establishment of direct connections. There are many other factors. One of them is the gradability of goods. In general, it may be said that commodities having such uniformity as to be accurately graded and sold by grade, can be and usually are sent directly to their destination with little regard to the entrepôt, while commodities that cannot be accurately described but

must be inspected before purchased are often bought and sold at some convenient intermediate point which has come to be recognized as a "market" for a certain commodity or commodities.

Wheat is an example of the gradable commodities. A buyer is reasonably certain what he will get when he buys No. 1 or No. 2 of a certain kind of wheat, graded in a certain market. Accordingly, ships load in Oregon, Argentina, or the Atlantic coast of the United States or Canada and start toward Europe. The cargo is sold en route by a cablegram, and the captain of the ship learns his destination by radio.

Effect of Ungradable Goods. Such transactions are impossible with the ungradable articles of which wool and ivory may be taken as examples. The value of these commodities is affected by so many conditions that they must be examined before being purchased. The sheep's fleece is often cut into five or six pieces at the shearing table, and the wool bale of commerce contains only one of these kinds. The value of the bale depends upon the skill of the wool baler on the sheep ranch. It also depends upon the breed, the ancestry, and the food of the sheep, which affect the length, fineness, and strength of the fiber. The character of the soil in different localities gives the raw wool a varying proportion of dirt; the heat of the climate and the variations of the seasons give it a varying percentage of grease; a drought and accompanying shortage of food reduce the physical condition of the sheep and make a weak place in the fiber. The wool buyer needs to consider all of these factors in purchasing. He must, therefore, see and feel the wool before buying, and a mistake in judgment may cause large financial loss. The wool buyer is a highly paid expert and it has always been profitable for the wool manufacturers of the United States, Great Britain, and the Continent to secure a large share of Australian wool (the highest grade of wool) at the London wool auctions, where careful inspection is much easier than it is in Australia.

Ivory is likewise of uncertain value. The age of the animal and the size and the previous treatment of the tusk are important factors, and an almost imperceptible fracture may nearly ruin an otherwise perfect piece. Ivory is therefore sold by auction. The greatest market is Antwerp, the largest supply coming from the Belgian Congo.

Conservative Influence of an Established Market. Commodities requiring inspection are not necessarily sold at auction. Private sales may give as firm a hold on international trade, once a city becomes the recognized place to buy and sell certain commodities. The entrepôt has a prop in that peculiar and conservative force—the drawing power of a "market." The drawing influence of an established market causes some cities to handle large quantities of goods which might now be handled to better advantage and with less labor elsewhere. The "market" often holds its trade in this day of direct connections by the force of mere custom and conservatism. Such is the Bremen tobacco market, which began with the establishment of a line of emigrant ships to the United States in 1827. At that time tobacco was almost the only return freight, and Bremen became the greatest European tobacco market. "Bremen is the market for hogshead tobacco, and everybody

buys here." Such were the words of a Bremen tobacco merchant when asked as to the cause of Bremen's control of the continental tobacco trade. Later came cotton, rice, grain, and petroleum. The fact that this city is a great rice market and had good eastern and western steamer connections long caused her to forward to the United States some East Indian rice that might just as easily have gone direct to New York. In comparison with Bremen, Hamburg had better steamship connections and decidedly better interior transportation; but Bremen held the tobacco market and the cotton, rice, grain, and petroleum markets for decades, although Bremen cotton firms tried to open branches in Hamburg, with the idea that they might eventually move to that city. The Hamburg branches failed just as have the efforts of London wool brokers to sell Australian wools (fine wools) at Liverpool auctions. In the same way Liverpool brokers have failed to sell carpet wools (coarse wools) at London auctions. The cause of these failures may be ascribed to the price-setting function of the established auction or market. In each of the above cases the goods offered in the unusual places were offered at reasonable or even very favorable rates, but the buyers made unreasonably low bids, and later they often paid more for the same goods at the established place. At the unusual place the buyer has the uncertainty of thinking that he might get a better article or more favorable price at the regular market with its larger stocks; so he bids cautiously. In the regular market he knows that here all sellers are bidding for his trade, and he buys. It is a kind of a supreme court of commerce.

Effect of Abundant Capital. The capital of the entrepôt serves as a prop to maintain its hold upon trade that might by existing direct connections go direct from producer to consumer.

The business of the international distributing center therefore increases or decreases with changes in the financial soundness and available capital of the trading countries. The merchants of the great center by having stocks of goods may, in a sense, serve as the bankers for, or partners with, the traders of countries where capital is less plentiful. Hence, as capital becomes more plentiful in the various countries, there is less need for and dependence upon the center. The German or Belgian manufacturers may not have the capital to invest in raw materials that must be purchased in South America or Asia in large quantities and weeks in advance, even if such purchases are desirable. Steamship connections make such a trade possible, but it may suit the manufacturer better to buy in London or Liverpool in small quantities as needed. An incident shows how this force works. In the opening years of this century many German woolen mills had established a direct trade in Argentine wools, to the detriment of the British merchants who had previously supplied them. Financial difficulties in Germany brought failure to a number of German mills and reduced capital and credit to others. The direct purchases in South America had to be discontinued, and a larger share of the wool supply again came through the centers of abundant capital—London and Liverpool. This case is an exceptional one in a time when the general tendency was toward the increasing financial independence that fosters di-

rect trade, but it serves as a forcible illustration of the influence of abundant capital on the entrepôt trade.

The history of the Liverpool cotton market illustrates this general tendency. About 75 years ago two-thirds of the American crop went to Liverpool, 2 million bales were often carried in stock, and the world price was fixed in that city. As the American dealers could not afford to store and hold it, they exported it as rapidly as possible, and in a few months the whole crop was disposed of. The continental buyer could not afford to send to America for it all at once, but took advantage of British capital by buying in small portions in Liverpool. But as capital became more abundant in the regions of cotton production and cotton consumption, there was a corresponding decline in the international importance of the Liverpool cotton market. American mills consume a larger share of the annual crop; American capitalists are able to hold the raw product; American speculation and American consumption set the world price. In many cases the cotton spinners of the continent buy directly from America; and Bremen, Le Havre, and Antwerp became rival markets with Liverpool. Some hasty purchases or small purchases are made in Liverpool, but the relative importance of that city has declined; instead of importing two-thirds of the American crop, her dealers now handle less than one-fourth of our exports. This control of the cotton trade because of capital advances is a type. The British have done it in many countries and for many crops. Examples are the early potatoes on the coast plain near Barcelona, and the Spanish table grapes of Almeria.

The Entrepôt Problem is Universal. The restraining influences are but exceptions in a general tendency. The day of the world entrepôt has passed, and its place is being taken by an ever-increasing number, so that we now have a score that are as large as was Amsterdam in her distributing prime, each handling as much trade as she did in that day. But the fact remains that of the many, many thousands of towns and cities upon the face of the globe, all but this favored score connect with the great arteries of commerce through some entrepôt of greater or less importance. Therefore, it is plain that the problem of the entrepôt is universal, and their number merely serves to heighten interest in them.

4. The Bargain Center

The Buying and Selling of Distant Commodities. A city may be a commercial center in two ways—first, as an actual distributer of goods; second, as a transaction center, a place where bargains are made for goods that are elsewhere and which may never be brought to the center. The transactions in C often relate to goods in A to be sent directly to B. The transaction center is the lineal descendent of the eighteenth-century distributing center. In the days when the communication of ideas and the carriage of goods depended upon the slow and uncertain sailing vessel, or the equally slow and uncertain means of land conveyance, it was usually necessary to have the goods on the spot before they could be the subject of bargain or sale. However, the steamship, the railway train, and the telephone, telegraph, cable and radio have made a

commercial world new in its methods of management as well as in its staple commodities. Electric communication gives instant and constant information concerning stocks on hand, the crop prospects, and other conditions that affect the prospective supply. Standardization either by manufacture or by grading makes it possible for buyer and seller to bargain definitely for commodities neither has seen or ever will see. The steamship gives quick delivery; and, what is of equal importance, it far exceeds the sailing vessel in the certainty of reaching port in a stated time. Commercial transactions of today may thus concern commodities in distant places and for future dates; and, although the movement of the goods may be decentralized, it still remains advantageous in a surprising number of cases for the men doing this work to assemble in groups at some convenient center.

Advantages of Centralized Bargaining. The sales and purchases are made in the center, because it is easier to carry on such operations where many buyers congregate, where many compete in the same business, and where representatives of many businesses can serve each other. This attracting force is somewhat akin to that of an auction, and it draws those engaged in the bargaining or transaction side of commerce into groups that are often quite irrespective of the location of the commodities in which they deal. This centralizing force operates in local, interstate, and international trade. It is usually strong enough to collect into a small district of a city all the firms engaged in the same line of business, provided the business is not of the retail nature requiring scattered location close to its patrons. The steamship agents and brokers of London, Liverpool, New York, and San Francisco are all collected into small districts of their respective cities through which one can walk in a few minutes. The London wool brokers have their still more restricted locality, and two or three small streets are the headquarters for the general produce brokers. The same is true of the leather merchants of New York and the paper dealers of Philadelphia. An hour's walk through the wholesale districts of New York, Philadelphia, London, Hamburg or any of many smaller cities will suffice to give the observer many examples of this grouping of mercantile firms engaged in the same business. This centralization has gone so far that some buildings are recognized as the center for certain industries.[10]

Examples of Centralization in Bargaining. The exchange, of which the stock exchange is a conspicuous example, represents the highest form of this grouping or centralization. There the principal buyers and sellers of a particular commodity actually congregate in a single room to facilitate their work. The exchange method of doing business may be applied to most commodities of which the price may be quoted. London has a stock exchange, a wool exchange, a metal exchange, Lloyd's (the underwriters' exchange), the corn exchange (grain), the coal exchange, the royal exchange (bankers, manufacturers, etc.), and the Baltic, the world's chief center for the chartering of tramp ships and an important center for the

[10] It is suggested that persons using this book as a text have local studies made in their respective cities and towns.

purchase and sale of full cargoes of grain,[11] timber, oil seeds, coal, and other commodities. New Orleans, Liverpool, and Bremen have cotton exchanges; Louisville has a tobacco exchange; and Leipzig a book exchange. Hamburg has one very large exchange, attended by most of the brokers and wholesale merchants of the city, where a variety of transactions take place, but the grouping principle works within this general bourse or exchange, for there is a steamship corner, a grain corner, a coffee corner, a stocks' corner, etc.

By similar centralization the manufactured products of an industrial district are usually sold at some central point to which in many instances they are never sent, being shipped instead directly from the factory to the point of final destination. Manchester is the selling center for the cottons produced in a score of smaller cities and towns in Lancashire. Offices in the business section of Philadelphia sell a large part of the manufactures produced in the mills of the suburbs and nearby towns. The same is true in Boston and many other large cities. Most of the shoes made in eastern Massachusetts are sold in a hundred or more offices located in a restricted area in Boston.

National Centers for Management of Foreign Trade. In the same way the transactions of foreign trade are centralized in the commercial metropolis. Decentralization of commodity traffic has been an accompaniment of the growth of the new commerce; but electric communication and the fast mail have helped to keep up the transaction center by putting the selling agent in easy touch with the factories and local centers of the producing and consuming districts in all parts of the world. Sales for the foreign trade or to the distant consumer cannot be arranged easily from cement works located in the Allegheny Mountains of Pennsylvania or Virginia, from the Georgia cotton mills, or from the phosphate mines of Tennessee or Florida. Consequently the selling agencies are in New York, although the cotton cloth may go to China by way of Vancouver Sound, the phosphate is shipped from a Gulf port to Japan, and the Virginia cement reaches the sea at Norfolk and Newport News, or goes by rail to interior points. The products of the scattered industries of Great Britain are largely sold in London, but tens of millions of pounds sterling worth of the goods thus sold go from the point of production to Liverpool, Manchester, Hull, Glasgow, Bristol, and other ports for export. Hamburg merchants or brokers sell a large share of the German export manufactures while they are yet in the mill, and the goods in question often go down the Rhine to Antwerp or Rotterdam for shipment. The Paris commissionaire renders a similar service in the French export trade, and in many countries the broker who makes a specialty of selling for many persons or firms brings about an important part of the transactions in foreign as well as domestic trade. There is a general tendency toward the establishment of direct connections between consumer and producer, especially when the currents of trade have become regular and confi-

[11] As much as 250,000 tons of grain, worth £2,500,000, has been sold in a single day on the floor of the Baltic Mercantile & Shipping Exchange.—J. A. Findlay, *The Baltic Exchange* Witherby & Co., London, 1927, p. 40.

dence is established; but the markets for the new industries or the new lines of trade in many of the old industries are found through the agencies of the selling center. Here also the new purchaser usually finds it is easier to purchase his stocks, and at all times the individual trader dealing directly has the opportunity to better his condition by selling through the transaction center and getting the advantage of a competitive market.

International Bargain Center. The transactions of the wider international trade are also centralized. London, the last great international distributer, is still a large international seller. With the convenience of telegraph, cable, and radio, the London distributing merchant often found that, upon the creation of direct communications between foreign countries, he could continue to make the bargains and arrange other details although the goods no longer passed through London. He knew the conditions of both Eastern and Western markets, and the direct connections that have sprung up merely enabled him to deliver more quickly by shipping his goods direct. Thus, the counting house stayed while the warehouse passed away. By this process, London has come to be a dealer in goods which may never at any time be within 5,000 miles of Great Britain. For example, London brokers and London merchants once had a practical monopoly of the international sales of pepper, Manila hemp, Indian jute, and Burma rice. The world's supply of each of these four commodities is produced in a comparatively small region and consumed all over the world. The high value and limited supply of the annual crop would probably lead to disturbing price fluctuations if the central London firms did not act as a sort of regulator. Being in constant communication with their numerous agents in the centers of both production and consumption, having a world knowledge of this particular trade, they are able to conduct business more safely than is the firm in New York or Marseilles, should it attempt to buy hemp, jute, or pepper directly from the dealer in the point of shipment. Under such an uncentralized method no man or set of men would have the knowledge of conditions in the producing and in all of the consuming centers; and it is probable that some one of the several centers of consumption would get too large a proportion of the annual crop to be successfully sold in its established markets; or it might by delaying purchase get too small a supply, producing scarcity and abnormal prices; or again the entire crop might not be purchased, and a surplus would be left to disorganize the next year's market. But as it is, the London firms have a geographical location that is central to the consuming regions of Europe and America, and because of their knowledge of the requirements of each section, the business is conducted much more evenly. A financial disturbance or failure in Spain or Holland or Sweden might cause the sacrifice of a shipment of pepper that had been purchased and was in transit. The Spaniard, acquainted only with a small local trade, would lose heavily by a sudden forced sale; but, if the London house had charge of the transaction, the shipment in question would be transferred to the next best market, which might be in the United States, in Scotland, or in Russia. It sometimes happens that such sudden changes

return to the broker's control goods that can be disposed of to good advantage in some other place where a new and unexpected demand has arisen.

The commodities that are subject to the centralized control of London sometimes go by London, Liverpool, or Hamburg for convenience of transshipment to final destination in America or Europe, but they more often go direct. For example, the Burma rice goes in full cargoes from Rangoon to Brazil and the West Indies, while shiploads of crude rubber from Singapore go directly to the United States.

The Influence of Capital. The international transaction center requires a central location, a line of business that is carried on in widely separated places, and, in addition, an abundance of capital. Often capital must be more plentiful in the center than in the commercial outposts, for the central management of a distant business operation is at times only possible by the use of capital from the controlling center. In this respect the relationship to the distributing center is again shown.

The London firms can hold the fiber trades only by buying the hemp in Manila and the jute in Calcutta. The rice distributing firms of Europe own the cleaning mills in Rangoon, Bangkok and Saigon. This central control goes further and sometimes takes a lien on the unharvested crops. The white grapes of southern Spain are usually sold in or through London to offset the account of the merchant-banking firm that has, through its local agent, advanced the money necessary for the expensive oak casks and cork packing. An American importer of these grapes bewailed his inability to buy them direct from Spain, but he could not break the hold of British money unless he had a bank in Spain. He was not a banker; so he got his grapes in London and sent them across on the fast trans-Atlantic liners at little if any sacrifice of time or freights. The long-established use of London capital has given the London capitalist a controlling voice in the sale of many products. For a long time much American cotton was controlled by British firms which advanced money to large cotton factors who advanced it to small cotton factors who advanced it to growers. The growing surpluses of American capital since World War I have made New York an important center for transactions of this nature.

Close Relation to Banking and Industrial Enterprises. The distant agents for London firms have brought and are bringing to London a great variety of transactions similar to the above. Further examples may be cited in the Persian wools, the dates of Arabia, and the cabinet woods of the tropics. The details of an actual case will illustrate this class of transactions. Some years ago a German firm, half merchants and half bankers, had head offices in Hamburg and branches or agencies in many other cities, among them a port in the Tehuantepec region of Mexico. In this port there was a Mexican promoter. He had a concession from the government to cut mahogany in the woods of the interior; he was familiar with the language of the Indians and with the local labor market; but he had no capital. He arranged to get the necessary money from the banker's agent who was acquainted with the conditions and took the risk as follows: first, the promoter was bound to deliver certain amounts of

mahogany as collateral for a certain sum of money for which he was to pay a good rate of interest; second, he was to receive the money in monthly installments as the work of getting out mahogany advanced; and, finally, the agent was to sell the wood, thus securing the payment of principal and interest—provided it brought a sufficiently high price. This was of course a part of the risk incurred in advancing the money. When the work was so nearly done that a date could be set for its conclusion and for the shipment of the lumber, the agent informed the head office in Hamburg. The principals entered into negotiations to secure transportation, and finally chartered a British vessel to load a full cargo and proceed to the English Channel for orders. In the meantime, efforts were made to sell the cargo but as no suitable buyer could be found in Germany, it was placed in the hands of a London broker who sold it to a Paris firm who ordered the vessel to proceed to Le Havre and discharge cargo.

As the trading countries come to possess more adequate supplies of capital for their own use, and when the trade assumes larger proportions, the international transaction center loses, at least proportionally. When the buyer and the seller can manage a transaction without mortgaging the goods in transit to a financier in a third country, there is less need of the services of the broker in the international transaction center. There is accordingly a tendency toward a decentralization of management as well as a decentralization in the actual handling of goods. But the two decentralizations do not accompany each other. The direct movement of goods precedes in point of time the direct management of the business. The latter may be indefinitely delayed. The supplies of capital may remain low, causing dependence upon foreign bankers. Few countries have or promise to have sufficient capital for their own needs. Since the commercial character of the traders in some countries is not reliable, no one dares trade with them who is not fully acquainted with them—which usually means having an agent on the spot, as happened in the Mexican lumber incident described above. The trade of some countries will therefore continue to be largely transacted through the centers in the financial countries, although many products, usually the raw materials, go directly to the ports nearest the points of consumption.

In the United States the industries are conducted upon an unprecedented scale, the mercantile classes are relatively reliable, and the accumulation of capital has been rapid. As a result direct bargaining arrangements have been established, at least for the staples of American trade. There is no single European center for the trade in American grain, cotton, or lumber. American merchants deal directly with a dozen European cities. Sometimes a London broker succeeds in placing a cargo of American grain or lumber in some other city, but this is unusual, and he must divide his brokerage with the agent in the other port. The grain cargoes from the Baltic and Black Sea ports are usually sold by London brokers, although they may go to any continental or British port. The same is true of East Indian teak, West Indian mahogany, and a large share of the Brazilian coffee that goes to continental Europe.

during the war of British foreign investments. World War II repeated it and increased it.

New York's dominance in international transactions is but a natural next step to its previously established dominance in the industries of America. A surprising amount of national and international business is done without leaving New York City. In New York are consummated the deals in Montana and Arizona copper, Oklahoma oil, Maine spruce lands, Georgia pine lands, California water-power plants, Virginia railways, Florida phosphates, West Virginia coal, Pennsylvania cement works, and the chartering of ships for Texas cotton. Most of the larger railroads of the country have offices there, and those who supply them must also have offices there. The list might be drawn out indefinitely, for there is not a state in the Union that does not have lands, enterprises, and resources managed from New York, the bargain center of America.

As this country invests more capital in foreign lands, the office signs of New York become more and more of a gazetteer of the world. The future is suggested by the important place taken by New York in the industries and railways of Mexico and by the Guayaquil-Quito railway which was built by an American company that has its headquarters in New York and did not even list its stocks on the London exchange. Men in this New York office make bargains for steel rails shipped from Pittsburgh, for ties shipped from Oregon, for cement shipped from eastern Pennsylvania. As never before, our commercial and financial frontiers are global. American firms with headquarters or offices in New York manage the banana and sugar plantations of the Caribbean area; mining enterprises in Canada, Latin America, Iraq, Iran, and Saudi Arabia; railroads and power plants in many Latin American countries; and branch factories on every continent. Chicago meat-packing companies have slaughterhouses in Argentina, Uruguay, and Brazil; a Chicago manufacturer of harvesters has sisal plantations in Mexico; (Ford of Detroit had rubber plantations in Brazil); Firestone and Goodyear of Akron have rubber plantations in Liberia and Malaya; and as time goes on, other American cities will engage in similar distant enterprises. The era of bargain centers is but begun.

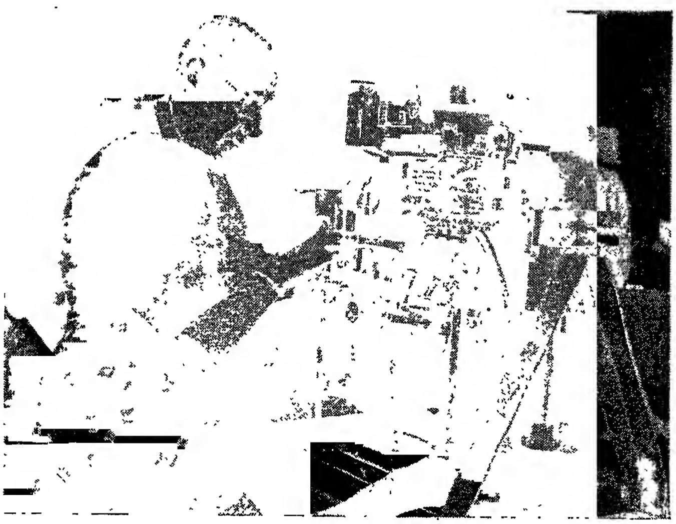
The Ocean and Its Carriers

1. The World Highway

To understand world commerce we must first know the part played by the ocean. The nation that does not touch the ocean is like a house that is not upon the street, and some of the bitterest strifes of history have been for the possession of bits of coast. Once a nation has reached the sea it has possessed itself of a part of the world highway that reaches everywhere and belongs to each and all who own even a tiny strip.

Cheapness of Ocean Transportation. It is an adage that ocean transportation is cheaper than land, but it is difficult for the landsman to realize how much ocean carriage differs from land carriage in cheapness and why. In a prewar year the average cost of transporting 1 ton of wheat 1 mile was 30¢ by wagon, 15¢ by motor truck, .65¢ by railroad, .3¢ by lake and canal including transshipment from lake carrier to canal barge, and only .1¢ by ocean vessel. In 1943, when all transportation rates were high, the cost of transporting petroleum was .83¢ per ton-mile by railroad, .32¢ by pipeline, .2¢ by barge, and only .12¢ by ocean tanker.

The relative cheapness of ocean trans-



The ocean is cheap to travel over and safer than it used to be, with steam, radio, radar, and the centuries-old compass, and the compass is better than it used to be. Perhaps you have seen a Boy Scout's compass. This picture is of a master compass, built in a hurry during World War II by an automobile corporation. It has about 1,800 pieces, it took 1,700 man hours of work to make and cost $4,270 installed.

portation is largely the result of three conditions. Nature provides the ocean shipping company with a free highway —no original cost, no upkeep, and no taxes. In contrast, American railroads in 1943 had a capital investment of $115,-288 per mile of line.[1] Secondly, water is buoyant. It bears the weight of the ship and its cargo, and only motive power is needed, while on land additional power must be used to overcome friction. The importance of friction is shown by the fact that a horse can haul 1 ton of freight in a two-wheeled cart on a level road but can pull 40 tons in a canal barge. On the average, American railroads in 1943 used 114 pounds of coal or its equivalent in other fuels to move 1,000 tons of freight and rolling stock 1 mile, or more than three times the fuel consumption per ton-mile of ocean-going cargo vessels. Thirdly, the ocean shipping business is one of the world's most competitive industries, and low rates resulting from competition benefit shippers and consumers throughout the world.[2]

2. *Tramp and Liner Shipping*

Two Main Types of Ocean Service. For more than a hundred years tramp and liner shipping have been the two main branches of the ocean shipping industry.[3] The principal feature that distinguishes the liner from the tramp is regularity of service. A liner is any vessel that operates over a fixed route on a regular schedule of sailings. Since a schedule of regular sailings can be maintained only with a number of vessels, the number depending upon the length of the route and the frequency of sailings, it follows that liners belong to a fleet or "line," and thus the liner derives its name. On the other hand, a tramp is any vessel that has no fixed route and no regular time of sailing and which is ever seeking those ports where profitable cargo is to be obtained. The tramp is a free lance that has earned its name from its gypsy-like existence, for it will carry cargo to almost any destination, and in the course of its wanderings the tramp may traverse every sea and circumnavigate the globe many times. In contrast with the liner, the tramp ship is a jack-of-all-trades.

Many liners carry passengers, express, and mail. Manufactured goods have long been a major cargo. The liner caters to cargoes requiring faster and more regular service than that afforded by the tramp, which seldom has a speed

[1] This figure includes not only the investment in roadway and tracks but also stations, engine houses, shops, signals, and other physical equipment. However, the ship's terminal is not *free.* Even in public ports there are charges.

[2] Other factors, of course, contribute to the relative cheapness of ocean transportation. The freight-carrying capacity of a railway train is broken up into many small units or cars, involving waste in the form of deadweight or tare, while the almost unobstructed hold of a cargo vessel has very little loss from deadweight. The cost of building an ocean-going cargo vessel and the amount of labor needed to operate it are much less than the cost of building and operating the equivalent in locomotives and freight cars. The average freight haul on the ocean is much longer than on the land, with the result that the ocean carrier has lower cargo-handling expenses per ton-mile.—See Erich W. Zimmermann, *Ocean Shipping,* Prentice-Hall, Inc., New York, 1921, pp. 3-19, and Abraham Berglund, *Ocean Transportation,* Longmans, Green & Co., New York, 1931, pp. 5-20.

[3] See C. Ernest Fayle, *A Short History of the World's Shipping Industry,* George Allen & Unwin, Ltd., London, 1933, pp. 253-270; J. Russell Smith, *The Ocean Carrier,* G. P. Putnam's Sons, New York, 1908, pp. 26-53; and *Report of United States Maritime Commission on Tramp Shipping Service,* House Doc. 520, 75th Cong., 3d Sess., Washington, 1938, a report that was prepared for the Commission by the junior author in 1937.

exceeding 10 knots.[4] The great majority of tramp cargoes are commodities (1) of sufficiently low value that cheapness in transport outweighs any value of speed or regularity in delivery, (2) of relatively large bulk or heavy weight, (3) that do not require exceptional facilities on the part of the carrier for preserving or handling them, and (4) that are available for shipment in full cargo lots. Grain, coal, sugar, cotton, lumber, and various ores are among the cargoes that are commonly carried by tramps.

A shipper who has enough cargo to fill a vessel may charter a tramp, just as one charters a truck or moving van that is available for private hire. It is an individual matter entirely between the shipper and the shipowner. The business is not heralded by expensive advertising, fine engraving and handsome cuts distributed throughout the six continents. All this publicity is costly. The tramp is on the list of some shipbroker or brokers who secure a freight for her on commission, and she goes about her work unnoticed by the traveling public or by the headlines of the newspapers. She is reported only in the maritime columns of the business journals, and is watched only by those whose business it is to know about her travels. But she carries a large proportion of the world's freight.

Unlike the liner, the tramp operates as a single unit of transport and does not conduct its operation in concert with other vessels. The tramp is free to fluctuate from one route to another in response to the shifting requirements of trade, while the liner is restricted to its route almost as rigidly as the railway train is confined to its track. The tramp is free to lie in port when work does not offer, thereby saving fuel, wages, and other expenses. The liner must maintain a schedule and make sailings to ports of call, which in themselves are often unprofitable, but which are necessary, since a line vessel must maintain a reputation to establish relations with shippers and form a clientele. The tramp usually carries the cargo of a single shipper, and it is free to choose the most profitable cargo that is available at a given time. The liner carries the goods of many different shippers, it does not discriminate among them, and it stands ready to accept the goods of all shippers provided that space is available and that shippers are willing to comply with the terms of freight. It is clear, therefore, that the tramp enjoys much greater flexibility in operation and management. The advantages of flexibility in management, a large carrying capacity due to the box-like construction of the ship (see Fig. 787), and a great saving in fuel because of slow speed enable the tramp to charge the world's lowest freight rates for the transportation of many low-valued, bulky, and heavy commodities. Tramp service is distinguished by its cheapness and flexibility; liner service, by regularity and greater speed.

The Charter of Tramp Vessels. The freedom of the sea makes competition easy, but it is especially easy among the tramp vessels. When a great line is established, full competition can only take the form of another great line, which involves much capital and careful organization. Competition in the tramp service requires merely another ship. It

[4] A knot is a nautical mile (6,080 ft.) per hour.

does not even require that the owner shall be a successful manager. He may rent his vessel out to another, who has the necessary acquaintance with the trade, or he may secure a manager who will receive a salary or commission. Any person who has the necessary two or three hundred thousand dollars can go to any one of the scores of shipbuilders and have a tramp steamer built in a few months.[5] He can have a ship built on part borrowed money, the builder taking a lien on the ship; and when she goes to sea she will go mortgaged. Or, if the newcomer should desire to engage in the ship business and does not care to wait for the ship to be built, there are numerous shipbrokers who will sell him one within an hour. The owner of this single ship is then in a position to compete in the world's freight market, and can take service on any sea, in any country and from hundreds of ports. The ocean is a world ocean; the ship market is a world market; the charter traffic is a world traffic; and the ocean rate a world rate. If there is grain in volume in the Black Sea, the ships go there, and the same is true of India, Australia, or South America. Wherever freight offers, there the ships may go and do go.[6]

The Tramp Traffic. This tramp steamer, which may be built and owned by anybody, and which may sail in all seas, and carry the products of any or all countries is a remarkably free agent. It is to be had, however, only by those persons who can afford to load a whole ship; and that is about the only limitation upon the character of produce that is carried by the tramp vessels. Nearly one-third of all tramp business consists of the carriage of grain, the remainder consisting of a wide variety of cheap and bulky commodities. Only occasionally some manufacturer ships enough heavy goods, such as steel rails, locomotives, and agricultural machinery, to fill a vessel, in which case he may charter a tramp. The regions producing the tramp freight and the regions consuming the same are widely scattered and embrace every important country in the world. For example, grain is shipped from our Pacific coast, our Gulf and Atlantic ports, from Argentina, from Australia, from India, from the Black Sea ports, and from Egypt. A further analysis of the origin and destinations of prevailing charter commodities would show that we have indeed a world problem. There are hundreds of ports with freight for tramp vessels, and there are thousands of ships scattered about the world to do this work.

Management of Tramp Vessels. The proper bringing together of the ships and the freight is a world puzzle, compared to which the game of chess is simplicity. The ships must move around the world in such a way that the freight

[5] Between World Wars I and II, the price of a tramp ship built in Great Britain fluctuated between a maximum of £258,700 in 1920 and a minimum of £32,000 in 1932.

[6] "Here is the *Olaf Nordsen* of Stockholm, Sweden (in New York harbor). She is about 8,000 tons and a heavy broad thing, with a short funnel, and two stumpy masts rigged with derricks. She looks a seaworthy ship and probably is. The Scandinavians are a hardy race of seafarers and know good ships. We will hail the man hanging over the stern and ask him when they left home.

"'A year ago,' he answers in broken English. 'Ve go to Vigo in Spain, den to Italy, den to Tunis. After dot ve vent to England, den come here.' She wouldn't have much speed, maybe ten miles an hour, and it would take time to travel all the distances she has been. And unloading cargo is a slow business in Spanish and North African ports."—*New York Times,* June, 1924.

is all carried and that the ships that do the work have as few empty voyages as possible, and keep constantly employed.

The successful adjustment of this complicated situation is a fine piece of applied geography. In its present form, it is one of the results of the development, first, of the ocean cable, and later of the wireless telegraph. Practically every ocean-going vessel now carries a radio outfit and is seldom out of touch with the world for very long. The Baltic Exchange and Lloyd's agency in Great Britain, with its branches throughout the world, report every observed movement of more than 25,000 vessels; maritime associations in commercial ports do the same work, so that the shipowner can easily know not only where his own vessel is, but where the vessels of his rivals are.

It is necessary, however, that in this work watch must be kept not only upon vessels but upon freight. Most of the cargoes consist of products that depend upon harvest and commercial conditions. If there is to be a good or bad grain harvest upon the Pacific coast or in the Argentine, tramp shipowners must know it and place their ships accordingly. The differing times of ripening of the various crops in the different producing regions and other particular seasonal demands make each port or district have its busy season and its off season. Accordingly, the manager of the tramp vessel has a number of problems to consider as he guides his ship through the maze of world commerce. The cable and radio which enable the Baltic and Lloyd's to report the movements of all vessels, also report the condition of crops in foreign countries, and enable the managers of the ships to maintain almost as good control and knowledge of their ships as does the chess player of the men on the board before him.

The manager of the tramp steamer must consider more than one cargo when he makes an engagement to perform a certain voyage, for it is necessary that his ship be discharged in a place where freight for the next trip is not too far away. Otherwise he may have a long voyage in ballast, making cost without income. The result is that the probable second voyage affects the rates for the first. The manager seeks an engagement which will release his vessel near good prospective freights, and he avoids engagements that take him into barren seas. Accordingly this master of applied commercial geography scans the world's horizon for prospective wheat crops or other freight supplies toward which he can work his ships with a chance of securing freight.

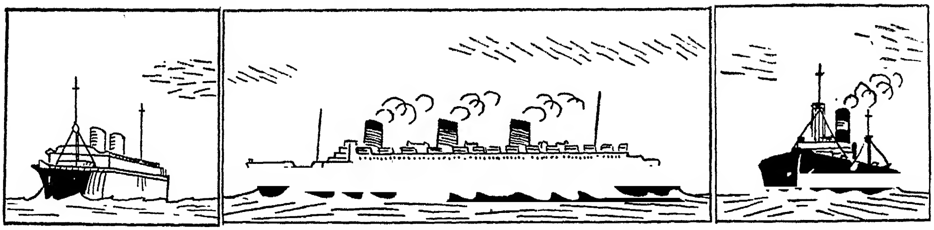
The Tramp Freight Rates. It is a fact that if a vessel cannot make good earnings, it usually pays better to take low earnings rather than nothing. The consequence is that when freight is scarce the rates may go down not only to a point where there is no profit but below this, because each manager reasons to himself: "If I cannot make profit, it is better to operate at least at cost; if cost cannot be made, it is better to operate at a moderate loss rather than to undergo a greater loss by tying up to a pier and allowing the ship to rust in idleness." The result is that ocean freights may go to great depths; and, conversely, they may rise to great heights, for when the freight is plentiful and the ships are scarce the only limit to which the rates may rise is set by the

maximum that the shippers can afford to pay to get a particular cargo carried. Charter rates jumped almost out of sight in the early months of World War I and World War II, and discarded old tubs of vessels were hastily overhauled and put into service, while new ones were still more hastily built. After each war freight rates declined sharply. The tramp shipping business booms in times of war, but its profits are normally meager. During the period 1922-37, the average rate of dividends paid on capital stock by British tramp shipping companies was less than 5% in every year except 1927 and 1928, and during the depression year of 1932 dividends averaged less than 1%.

The method of making rates and securing cargoes for ships, and ships for cargoes, is best described by the relation of some common incidents of everyday occurrence. Some years ago a Liverpool shipowner had a steamer in the Mediterranean loaded with jute, which she was carrying from Calcutta to Dundee. The owner desired another cargo for the steamer at the end of the voyage. Knowing that there was nothing in Dundee, he communicated with his agent in Newcastle, and himself made inquiries among the shippers of Liverpool. The Newcastle man suggested a cargo of coal to Hamburg, but it was declined; and the owner sought the aid of his correspondent in Dumbarton, but the iron trade of Dumbarton was not promising. Meanwhile the days were passing, the vessel had reached Dundee, and there was nothing provided for her.

The Liverpool man was himself the correspondent of a London firm of shipbrokers, who telegraphed him at this juncture that they had offers of a shipment of German coke to go from Rotterdam to Santa Rosalia, Lower California, and of another of Cardiff coal for Buenos Aires. The shipowner declined the Lower California job, and because of news from across the Atlantic he allowed the second to go to a steamer then lying at Antwerp. Three days before this he had cabled to his New York correspondent a description of the steamer, offering her services to carry grain to the United Kingdom at a certain rate and saying that she could load after a certain date or between certain dates. As New York freight was dull, the firm in that city telegraphed their Boston and Philadelphia agencies. At the same time a Chicago grain exporter decided to export 150,000 bushels of wheat, and telegraphed to his agents in New York and Philadelphia to secure offers of transportation. The representatives of the Chicago exporter and the Liverpool shipowner bargained face to face in the New York Produce Exchange. Offers were, however, made at the same rate by the New York representative of the owner of a ship then off the coast of Brazil with a cargo of manganese ore bound for Baltimore and also by a Philadelphia broker who sought future employment for a vessel then in the Mediterranean Sea with a cargo of Turkish chrome ore for the Atlantic coast of the United States.

The Liverpool owner was informed of this competition, and still having nothing for his steamer he cabled that he would charter his ship for threepence (six cents) less per ton, or, for the same rate, he would take freight to continental ports as far as Copenhagen.



These three somewhat symbolized drawings represent, at the right, the nearly boxlike tramp, at the left, a high-class liner, in the center, the supreme luxury liner, *Queen Mary,* with quadruple screws, driven by turbine engines, 180,000 horsepower, 30 knots speed. Dimensions: 1,018 feet by 119 feet by 68 feet deep.

He added to his cablegram the word "range," which means in cable code that he would send the ship to the United States with the understanding that she might be ordered en route to go to New York, Philadelphia, Baltimore, or Norfolk to load. This offer secured the freight, for the representatives of the manganese ship and the chrome ship having more time at their disposal preferred to take chances rather than cut rates. The steamer, which, pending negotiations, had proceeded to Newcastle to coal, departed thence in ballast for the Delaware Bay. Meanwhile the Chicago exporter found that railroad conditions made Norfolk the most convenient port to deliver his wheat at the appointed time. When this decision was made, the captain received instructions by radio to go to Norfolk. There he loaded a full cargo of wheat, and, as the final destination of the wheat was still undecided, he sailed to the English Channel. As he neared the British coast, he was instructed to proceed to Copenhagen, where the wheat was discharged. The vessel was now ready for another contract which the agents had been trying to arrange since the day they learned of the final destination of the wheat cargo.

Dependence of Modern World upon Both Tramps and Liners. This tramp traffic bears a very fundamental relation to world commerce because it carries raw materials and foodstuffs, without which the manufacturing city and the manufacturing state as at present constituted could not exist. The tramp is much like the slow freight train, while the liner resembles the fast express. The tramps handle the trade of vast quantity; the liners handle the trade of high value and the shipments of small size and great number. The liners, therefore, serve the greater number of shippers. They serve the multitude who cannot fill a ship with one consignment, and among manufacturers there must be many thousands of small shipments of finished goods to one that requires a tramp to handle it.

The manufacturing state depends upon tramps to bring food and materials, but there is an equal dependence upon the liners that carry to market with greater speed the myriad small consignments of manufactured goods and other commodities. Conversely a raw-material-producing country depends largely upon tramps to take its exports and upon liners to bring its imports of valuable manufactured goods. The trade

of Argentina is an interesting example. It moves as follows:

Inbound:
- British coal—tramp.
- Petroleum—tanker.
- Manufactures—combination passenger-cargo liner, and general cargo liner.
- Cement—both tramp and general cargo liner.
- Machinery—chiefly liner.
- Henry Ford's industrial carriers carry trucks and cars southward and flax back to U. S.

Outbound:
- Wheat, corn, flaxseed—tramp.
- Wool—liner.
- Meat—refrigerator vessel.
- Flour—liner.
- Quebracho extract—liner.
- Quebracho logs (few)—both tramp and liner.

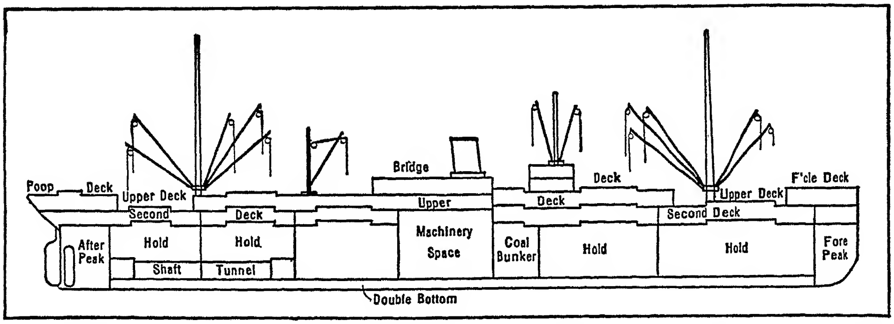
3. *The Decline of the Tramp*

Extent of Decline. At the end of the nineteenth century, the tramp held a dominant position in world trade and shipping, for it surpassed the liner in numbers, gross tonnage, potential carrying power, and the actual movement of freight. Throughout the present century the relative importance of the tramp has been steadily declining. In 1914 more than one-half of the world's ocean-going merchant vessels were tramp ships, which handled more than two-thirds of the world's ocean freight. In 1937 less than one-third of the ships were tramps, and they hauled considerably less than one-half of the freight. Between 1914 and 1937 the tramp's share of the total gross tonnage of merchant shipping declined from 46% to less than 30%.[7] Furthermore, the average speed of liners has been steadily increasing, while that of the tramp has remained about 10 knots, and it is doubtful whether tramps now provide as much as one-fifth of the potential carrying power available to shippers.[8]

During the last quarter of a century many bulky commodities have been deserting the tramp, and a few examples

[7] To the layman, the shipping fraternity's use of various kinds of tons is a confusing bit of nautical pedantry. Thus, a Liberty ship is rated at about 10,500 tons when it is launched, 7,200 tons if it is sunk, and only 4,400 tons when it enters and clears a port! A *gross ton* is 100 cubic feet, and the gross tonnage of a vessel indicates the cubic contents of the ship in terms of units of 100 cubic feet, minus certain deductions permitted by international agreement. Gross tonnage data are commonly used in comparing the merchant marines of the world, war losses, etc.; they are used in Lloyd's Register of Shipping; and they are found in the official merchant marine statistics of governments throughout the world. A *net ton* is also 100 cubic feet, and the net tonnage of a ship roughly indicates the space available for passengers and cargo. Net tonnage data appear in port records of entrances and clearances, and they are used as a basis for tonnage taxes and dues, etc. A *measurement ton* is 40 cubic feet, this unit being used by the shipbroker in selling cargo space to shippers. A *deadweight ton* is 1 long ton or 1 metric ton, and the deadweight tonnage of a vessel indicates the cargo-carrying capacity of a freighter in terms of weight. For tramps and general cargo liners, the ratio between net, gross, and deadweight tonnage is about 3 to 5 to 8. A *displacement ton* is 1 long ton or 1 metric ton, and the displacement tonnage of a vessel equals the weight of the water that the vessel displaces. Displacement "light" indicates the weight of the vessel together with the weight of a normal crew and supplies. Displacement "loaded" is the weight of the vessel, crew, and supplies, plus the weight of bunker fuel and cargo. The difference between displacement "loaded" and displacement "light" indicates the maximum carrying capacity of the ship (weight of cargo and fuel), or its deadweight tonnage. The British never adopted the beautiful and scientific metric system, and this mess of tonnage concepts is a beautiful example of the British system of keeping the old and putting on a patch or an addition to accommodate the new.

[8] If two ships have the same cargo-carrying capacity but different speeds, the faster ship can offer more transportation service per year. The potential carrying power of a ship is determined by multiplying its net tonnage by its average speed. In 1914 liners exceeded tramps in potential carrying power.



Longitudinal section of ordinary cargo ship, period of World War I; 429 feet long, 4,000 indicated horsepower, hold capacity, 461,923 cubic feet, 11,548 tons.

TABLE 46

ESTIMATED GROSS TONNAGE OF TRAMPS AND ALL OTHER TYPES OF VESSELS IN THE MERCHANT MARINES OF VARIOUS COUNTRIES, 1914 AND 1933

(In millions of gross registered tons)

Nation	*Tramp tonnage in 1914*	*All other tonnage in 1914*	*Tramp tonnage in 1933*	*All other tonnage in 1933*
Great Britain...	10.08	8.46	5.50	13.20
Japan..........	.50	1.21	2.38	1.88
Italy..........	1.05	.62	1.89	1.26
Norway.......	2.10	.41	1.65	2.43
France.........	1.10	1.22	1.56	1.95
Greece.........	.70	.12	1.32	.10
Sweden........	.80	.32	.87	.81
Spain..........	.65	.25	.85	.38
Holland.......	.50	1.00	.65	2.12
Denmark.......	.60	.22	.65	.52
British Dominions *........	....	....	.50	2.72
Germany.......	.50	4.93	.45	3.45
United States † .	....	5.32	....	13.47
Other Countries.	2.65	1.99	3.95	1.43
Total......	21.23	26.07	22.22	45.72

* Data included under Great Britain in 1914.
† Data includes 2.3 million gross tons in 1914 and 2.8 million gross tons in 1933 on Great Lakes.

Source: Adapted from Franz Lohse, *Die Entwicklung der Trampschiffahrt in der Nachkriegszeit*, Dresden, 1934, pp. 13 and 45. Greek data for 1914 were supplied by Mr. K. L. Rankin, American Commercial Attaché, Athens, Greece, in his letter of November 22, 1934.

may be cited to illustrate the trend. Grain has long been the tramp's major cargo, and prior to World War I a liner seldom accepted grain except when a few hours before sailing time it was found that no other cargo was available. Since 1920 many liners have engaged in the carriage of grain, and in recent years little more than half of the grain trade has remained in the hands of the tramp.[9] Iron ore, phosphate, sulfur, and cotton were once handled almost entirely by tramps, but more than one-half of the overseas movement of these commodities is now handled by liners. Prior to World War I, case oil (petroleum shipped in 4-gallon cans) was the chief tramp cargo shipped from the United States to China, but today virtually all petroleum moves by tanker. Tramps were once commonly chartered to bring bananas to the United States from Caribbean lands, but less than a dozen tramps are now engaged in this trade. The tramp still handles most of the world's overseas trade in coal, sugar, lumber, wood pulp, and newsprint stock, but in certain traffic areas desertions to the liner have been important.

[9] The chief grain movements by tramp, in order of importance on the basis of weight, are wheat, corn, rice, rye, barley, and oats.

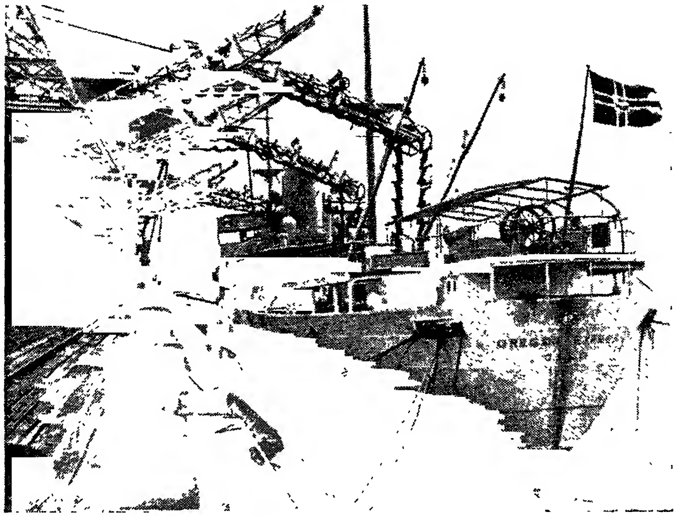
Specialization in Ship Construction. Like many another jack-of-all-trades, the tramp has suffered from the increasing competition of specialists. The

Air view of a Victory Ship, built in the later part of World War II. You can look down upon various hatches that give entrance to the holds and also see that she is armed.

tramp is little more than a sea-going warehouse designed for general utility, and specialization is precluded in its construction and equipment. On the other hand, the liner more and more is becoming a mechanized cargo-handling machine. The liner serves the same ports throughout the year and handles approximately the same types of products. Liner companies can forecast with reasonable accuracy the major requirements of their routes. Hence, as trade grows in volume and regularity, the liner company finds it profitable to adapt vessel construction to the cargoes carried and to the peculiarities of particular trade routes.

The degree of specialization varies all the way from the installation of a few extra gadgets for handling cargoes to the construction of new types of vessels for the carriage of a single commodity. Probably the most specialized merchant ship today is the self-unloading carrier, such as the colliers which make quick trips from Great Britain to the Continent with coal and which always return in ballast. This type of vessel cannot be employed in any other trade. Ore carriers with unusual ballasting arrangements and other special equipment handle only certain types of ore, as in the iron-ore and sulfur trades. Some refrigerator vessels specialize in the carriage of chilled beef; others, frozen mutton. Banana carriers have refrigerating and ventilating apparatus to preserve their perishable cargoes. Most tankers carry petroleum, but some are especially designed for molasses, latex, vegetable oils, whale oil, and other liquid cargoes. Many of these highly specialized vessels are operated by big corporations that own both the ship and the cargo. Others are operated by regular shipping companies that serve the general public. Virtually all of them are employed in liner service, running on schedule over established routes.

Although specialization in ship construction has led to a great diversity of ocean carriers, it is possible to divide the world's merchant vessels into eight ma-



The banana boat with belt conveyors to lift bunches of bananas from the hold, carry them up, over and down the pier. This is one of the increasing number of specialized ship types.

jor types. The names and distinguishing features of each of these types are presented in Table 47. An examination of this table reveals that there is a considerable overlapping of the characteristics of the different vessel types. For example, a combination passenger and cargo liner may be exactly the same as a general cargo liner in size, speed, and general equipment, the only difference being that the former carries some passengers. Again, a general cargo liner and a tramp may be identical in their physical aspects, the only difference being that the liner is engaged in regular service.[10] The significant fact is that the eight major types of vessels meet the particular requirements of their respective trades. The shippers of the world are demanding something more than cheap transportation, and the role of the tramp continues to decline.

Other Factors Underlying the Decline of the Tramp. In addition to the increasing specialization in ship construction and equipment, two other carrier developments have enabled the liner to invade the domain of the tramp: (1) the continuous cheapening of speed and (2) the shift in fuel from coal to oil. As a general rule, tramp owners have been slow to adopt new or improved engine types. Improvements in the steam reciprocating engine, the use of the geared turbine, and the development of the oil burner and the Diesel engine have occurred predominantly within the field of liner shipping. In 1914 less than 3% of the world's merchant tonnage was driven by oil; in 1938, more than

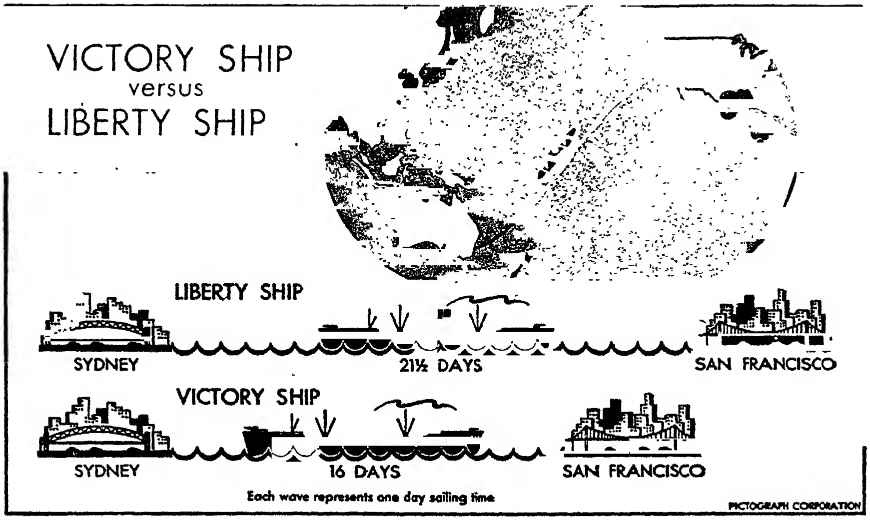
[10] It should be noted that the tramp-liner and the tramp-tanker are more nearly liners than tramps. Both tramp-liner and tramp-tanker are usually chartered on a long-time basis. Although the charterer sometimes shifts them from one route to another, they are usually operated on schedule in definite trades rather than seeking cargoes throughout the world. Nearly all Norwegian tanker tonnage is of the tramp-tanker type.

TABLE 47

A CLASSIFICATION OF MERCHANT VESSELS *

Type of vessel	*Service*	*Cargo*	*Equipment for cargo*	*Gross tonnage, approximate data*	*Speed in knots, approximate data*
Passenger Liners	Member of a fleet in regular line service.	Passengers, mail, express, and small amount of high-grade freight.	General.	20,000 to 85,000	20 to 33
Combination Passenger and Cargo Liners	Member of a fleet in regular line service.	(a) Primarily passenger and mail (b) Half and half. (c) Primarily freight.	General, with occasionally tanks for liquid cargo, refrigerated holds, etc.	8,000 to 30,000	12 to 20
Specialty Carriers	(a) Member of a fleet in regular line service, e.g., refrigerator ships, colliers, ore carriers, tankers, etc. (b) Independent vessels, usually on long-time charter, in quasi-regular service.	Freight, usually in full cargo lots, and occasionally some passengers.	Highly specialized.	3,000 to 15,000	10 to 15
Industrial Carriers	Member of a fleet in regular line service, controlled by company that owns the cargo, e.g., tankers, colliers, ore carriers, refrigerator ships, general cargo vessels.	Freight, usually in full cargo lots, and occasionally passengers.	Specialized or general.	2,000 to 15,000	Under 15
General Cargo Liners	Member of a fleet in regular line service.	Freight, usually in parcel lots.	General, with occasionally tanks for liquid cargo, refrigerated holds, etc.	3,000 to 15,000	10 to 18
Tramp-Liners	Independent vessels, on time charter, in regular trades most of the time.	Freight, chiefly bulk cargo, but often some cargo requiring specialized equipment.	General, and frequently specialized equipment such as holds for refrigerated and liquid cargoes.	3,000 to 10,000	12 to 14
Tramp-Tankers	Independent vessels, usually on long-time charter, in quasi-regular service.	Freight, liquid cargo in full cargo lots.	Specialized.	3,000 to 15,000	10 to 15
Tramps	Independent vessels, on voyage or time charter, no fixed schedule or route.	Freight, usually in full cargo lots.	General.	2,000 to 7,000	11 and under, usually about 10

* Prepared by M. Ogden Phillips, Professor of Economics and Commerce, Washington and Lee University.



Comparison of the Liberty Ship built for basal work during the war and Victory Ship built during the later part of the war for war and postwar use. After World War I, bunches of ships like strings of fish lay around various harbors from Basra to Baltimore, rusting their lives away. After World War II the same thing is likely to happen to many of the stupendous number of Liberty Ships that we were able to turn out to beat the German submarine.

standard of work.

50%. The oil burner has been used exclusively by liner shipping, and the Diesel has been adopted by tramp owners very slowly.[11] Not only have the advantages of oil as fuel accrued predominantly to the liner, but the tramp has suffered from the loss of many coal cargoes that formerly were carried to fueling stations throughout the world.

Various cargo developments have also contributed to the ascendancy of the liner. Following World War I, there was a great increase in hand-to-mouth buying in impoverished Europe, causing much grain, cotton, and lumber to move in parcel lots by liner, and this tendency continued until the outbreak of World War II. For decades there has been a growing trend for raw material producing countries to ship manufactured or slightly processed goods instead of raw materials, for example, flour instead of wheat, quebracho extract instead of logs, and copper matte instead of ore. Improved marketing methods have considerably reduced the seasonality in the movement of grain and other agricultural products, thereby reducing the need for the flexible service of the tramp. Furthermore, the movement of many minerals has become so large and regular as to warrant the use of general cargo liners, specialty carriers, and industrial carriers. These changes have been accompanied by an increasing ability of the liner to approach tramp rates.

Not least among the factors contributing to the decline of the tramp has been the rise of the industrial carrier to a

[11] While British tramp owners have adhered to the use of coal, the progressive Scandinavians were quick to adopt the Diesel tramp. Among the chief advantages of using oil instead of coal are: much longer voyages without refueling, lower labor costs in the engine room, greater speed in bunkering, and less bunker space needed for petroleum than its equivalent in coal.

position of major importance in world shipping. The big corporation has often found it profitable to provide the transportation of its own products. Among the products now carried by industrial carriers are petroleum and other liquid cargoes, coal, iron ore, bananas, meat, sulfur, bauxite, heavy steel, lumber, canned fish, and automobiles. We might almost say that the big company owns everything it needs.

The Future. While there are many forces that will contribute to the further ascendancy of the liner, it is not to be assumed that tramp shipping is doomed. So long as heavy and bulky commodities must have cheap transportation, there will be a demand for the services of the economical tramp. So long as the demand for ship space is disturbed by such vicissitudes as wars, famines, plagues, earthquakes, locusts, droughts, strikes, bumper crops, and crop failures —and so long as the movement of cheap and bulky cargo is subject to seasonality and irregularity—there will be a need for the flexibility of the tramp. The tramp will undoubtedly continue to decline in relative importance, but for some time to come it will continue to serve as the ubiquitous factotum of the Seven Seas.

. . . 26

The Trade and Trade Routes of North America

1. Easy Development of Trade Routes

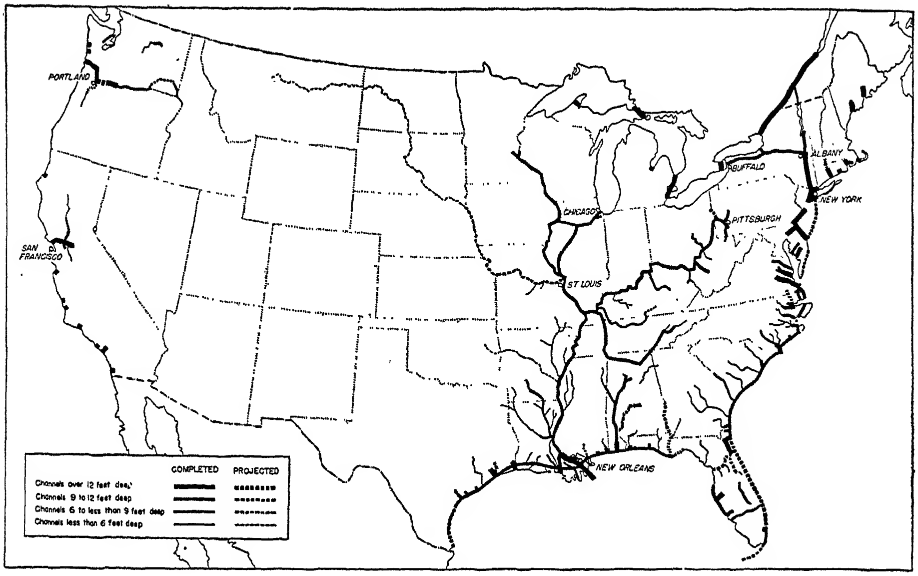
The internal trade of the United States is vast; the country is almost a world in itself, so great is the variety of natural resources. Not since the founding of the Republic has there been any tariff between the states to interfere with the full development of regional specialties.[1] This great, unmeasured domestic trade is favored by nature in many ways.

The surface and contour of the North American continent offer easier paths for commercial routes than those of any other continent except Europe. Most of the habitable areas are comparatively near to, or easily reached from, healthful coasts and suitable harbors. The tropic section is the only exception to this, and the tropic is of far less importance than the temperate section.

The center of gravity in North American industry, population and commerce is, and will long continue to be, in the southeastern temperate region, the region comprising the Atlantic slope, the basin of the Great Lakes, and the Mississippi Valley east of 100° W. This section is especially favored for transportation within itself and for access to the sea. The slightly sunken coast line affords numerous good harbors, with value increased by a moderate tide. Inland waterways are afforded by the Great Lakes, the Mississippi, the St. Lawrence, and the rivers and bays of the Atlantic coast and plain. There are few mountain obstructions, and the interior offers a most remarkable combination of conditions favorable to easy transportation. The Mississippi Valley is almost level, opens broadly to the Gulf, and further has the phenomenal advantage of almost imperceptible passages to the Lake Basin, to the Atlantic slope, and to the areas draining into the Hudson Bay and the Arctic Ocean. The problem of getting out to the Pacific, although of considerable difficulty, is easier than crossing the Alps or the chief mountains of Asia or South America. In Mexico and Central America the mountains are more difficult and the plains less hospitable. Excellent climate and abundant natural resources in the temperate sections complete the conditions necessary for the development of trade routes unrivaled in the size of their commerce.

We have strangely failed to utilize all

[1] In the 1930's there was a great upsurge of tariff feeling and our state legislatures passed hundreds of state laws, restricting trade between the states. For example, in one state no egg could be advertised or offered as fresh unless it was produced in that state—one of the myriad manifestations of the troublesome fact that abundance has become the Economic Devil of the Machine Age.



The eastern half of the United States is well supplied with main water routes. More carefully planned use of resources would cause them to be of greater service than they are.

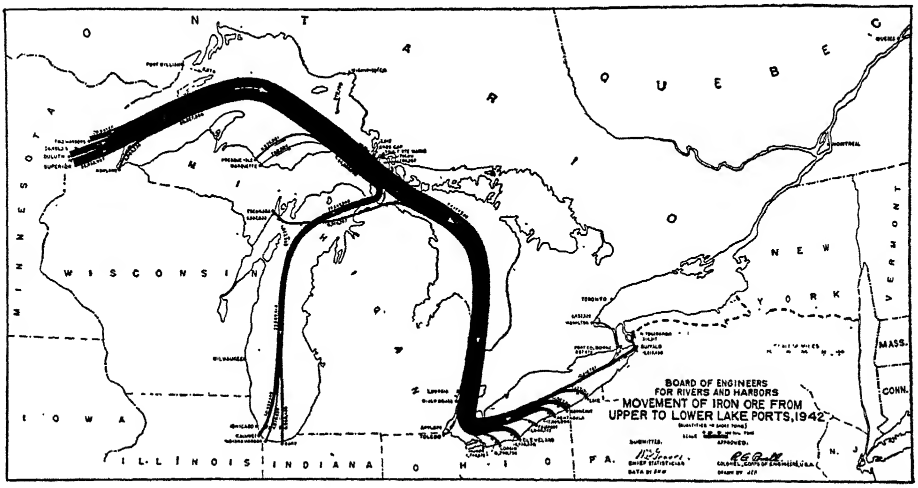
our advantages, especially our waterways, of which President Theodore Roosevelt in a message to Congress said: "Our river systems are better adapted to the needs of the people than those of any other country. In extent, distribution, navigability, and ease of use they stand first. Yet the rivers of no other civilized country are so poorly developed, so little used." There has been a pickup since that message went to Congress, and the waterways rendered great service during World War II, but the general charge of insufficient use still stands. The waterways have languished, and the railroads have thrived because we have been an individualistic rather than a social people. The individual or corporation could make a fortune from a railroad, while the river, free to all, merely interfered with the monopoly of the railroad interests and favored the shipper rather than the carrier.[2] The most conspicuous exception to this was the Great Lakes, a utilized waterway, upon which the railway companies once ran many boats which merely became extensions of the railroads. Before the coming of railroads, this country, like many others, was dependent upon rivers to an extent now little known. Thus the Ohio and Mississippi rivers were the first great avenues of trade, travel, and settlement in the country west of the Alleghenies, which they commercially dominated till 1850. But these streams were not adequately improved, and the Great Lakes were; hence they dominated the mid-continent commerce of the last half of the nineteenth century as the Mississippi dominated the first half.

[2] If you wish to see a good example of this operation of special interest vs. the nation dig into the story of the opposition to the St. Lawrence waterway.

2. *Trade Routes of the United States and Canada*

Influences of the Great Lakes in Making Routes. The primary routes of the continent are those connecting the upper Mississippi Valley and the Great Lake Basin with the Atlantic. Curiously enough, the main thoroughfare to this region is not by way of the St. Lawrence with its great estuary, nor by the navigable Mississippi, but through the low plain connecting the Hudson Valley and Lake Ontario. On the south navigation from the distant Gulf of Mexico was tightly shut off until the steamer came (1812), and on the north it is still shut off by Niagara Falls and the rapids of the St. Lawrence save for boats that can carry about one-fifth as much as the lake boats. The Ohio Valley frontiersman, in the day before the steamboat, took his flatboat load of produce to New Orleans, sold it, sold the boat because it could not be got upstream, and walked home with his silver dollars. His few import goods he bought from another flatboat that came down from Pittsburgh, the end of a long wagon journey from the Atlantic. The Mohawk River, flowing out through the only complete break to be found in the Appalachians between Maine and Alabama, gave the key to the lake commerce.

The completion of wagon roads across the state of New York about the beginning of the century was followed by the opening of the Erie Canal in 1825, the first extensive canal in the United States. The tapping of the lakes by this canal was revolutionary for the commerce of the West. The fact that the St. Lawrence drained the waters of the lakes was now of no avail. The Erie Canal drained their commerce into the Hudson, and it made commerce. A barrel of flour, which before this had consumed its profit in paying wagon freight for a hundred miles, could now be taken from the lakes to the sea for a tiny fraction of the former prohibitive freight. A large territory in the heart of the continent was given commer-



But for these lakes, American iron and steel would be distinctly more costly than it is.

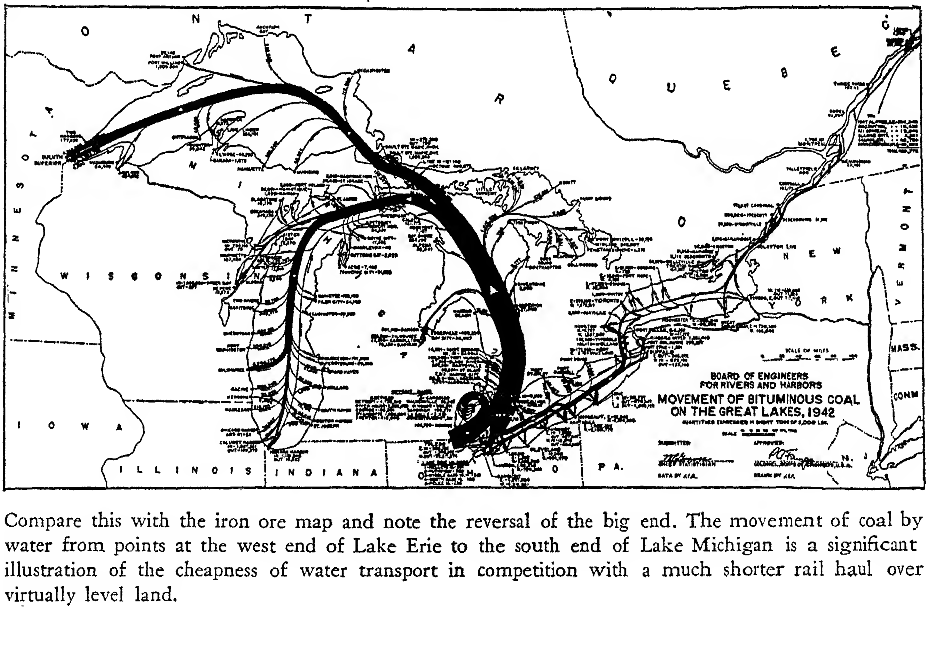
cial possibilities, because the new route made possible a commerce with Europe by way of New York. Lake shore points throve, having access to the sea through the canal. They also became the bases for the starting of railroad lines into the Corn Belt states a few years after the Erie Canal had virtually made the lakes into a commercial arm of the sea. The building of railroads to the West was most easily accomplished along the open route followed by the Erie Canal. This was a profitable place, too, for the building of a railroad, because here were already in existence the traffic-breeding centers of population that had grown up in the territory enriched by the canal that had made cities in the wilderness.

A good picture of one end of a canal lock. A similar gate at the other end of the lock holds the water in the canal while it is allowed to run out of the lock and let the boats settle down to the lower level. By the reverse process, the boat is lifted as the lock fills.

A stainless steel train on its speedy way from New York to Chicago. This picture and the previous one of the canal might be called "The Rivals."

The Great Lakes thus have dominated the development of trade routes in the railway era. Along their shores are the greatest interior populations and trade. The lake freight rates, which have been and are but a fraction of land rates, were a freight attraction that gave any lake port commercial command of the territory behind it. The lake shores have, therefore, always been magnets to the railway builders. Whenever possible these men have brought their lines to the lakes at some point or points so that they might ship east by boat and get a share of the water-borne lake traffic, going west. Consequently the Great Lakes have been the deciding factor in locating at least one terminus of most of the railroads of the Middle West and also of lines to the east of the lakes. The trade routes of this region may now be likened to a section of a thick cable woven of many strands which are untwisted and spread out fan-like at both ends. The lakes, with their steamship lines and the competing and auxiliary railways that follow their shores, make the central or compact section of the cable. The loose ends are represented by the many lines of railway that converge at the western lake ports, and by the other lines that diverge from the eastern lake ports to the Atlantic coast.

Western Assemblers of Lake Traffic. Chicago is at the tip of the lake that reaches farthest into the Corn Belt. All routes from the East to the vast American Northwest were compelled, in rounding Lake Michigan, to pass this point, which naturally became the greatest railway center in the world. Cleveland, Toledo, and Milwaukee had less commanding positions and grew less rapidly. Duluth, at the head of Lake Superior, is the gateway to a territory that, although much later in its development than that around Chicago and much less favored by climate, causes a

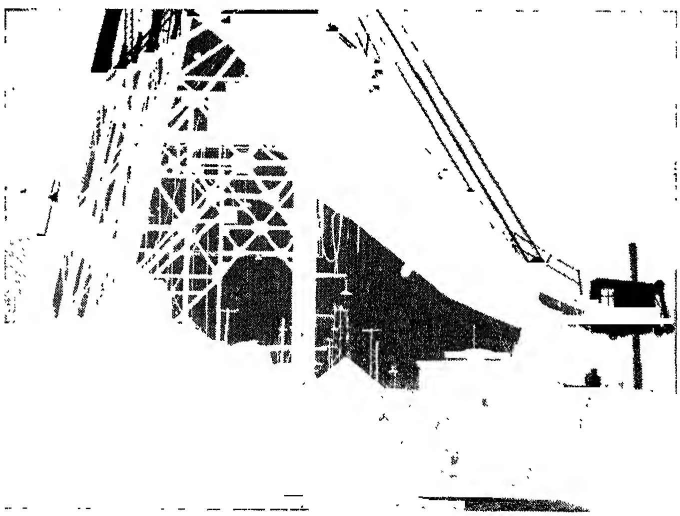


Compare this with the iron ore map and note the reversal of the big end. The movement of coal by water from points at the west end of Lake Erie to the south end of Lake Michigan is a significant illustration of the cheapness of water transport in competition with a much shorter rail haul over virtually level land.

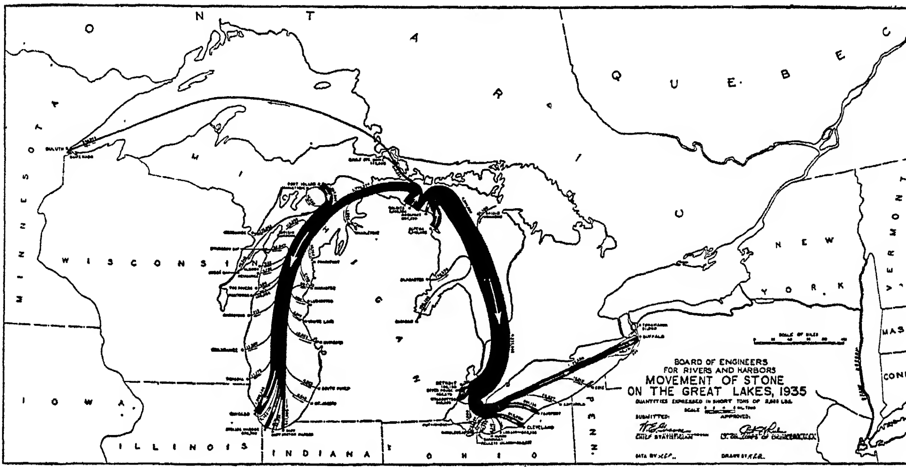
large and increasing volume of freight, both outgoing and incoming. Port Arthur and Fort William, Canadian cities at the western end of Lake Superior, are sister cities and also rivals to Duluth, sharing with her the forwarding trade to and from the spring wheat country to the westward. These cities at the head of the lakes, however, are not great trade centers, but merely points of transfer.

Once the railways have brought their grain, lumber, and ore to the lake ports, water transportation renders a great service. From Duluth, Port Arthur, and Fort William on Lake Superior, from Milwaukee and Chicago on Lake Michigan, and from Toledo on the Maumee near Lake Erie, a vast fleet of steamers and barges busily and cheaply carry freight to and from Cleveland, Buffalo, and even Montreal on the east. But the railroads because of their greater speed are also busy with the east and west traffic. North of the lakes, between the lakes, and with many lines south of the lakes they keep up a constant competition with the lake vessels, and, in the winter months when the lakes are frozen, they must carry all the freight. The railroads also get at all seasons the vast amount of high-class freight for which there is need of haste. Thus, meat, one of the greatest products in value in the whole Great Lakes basin, goes eastward chiefly by rail from the great packing centers of Chicago, Kansas City, Omaha, and Sioux City. The eastbound grain from these same markets gravitates toward the lake steamer, since speed and temperature are not so important in its transit.

The Traffic of the Lake Region. In numbers of tons per year the traffic through the American and Canadian canals around the rapids at Sault Ste.



The dumping of a carload of coal in about the same way that you would dump the sugar out of a bowl, is one of the factors in cheap lake transport. This picture indicates the method—car runs up the incline plane at left, is lifted up the tower opposite the end of the chute. Here the car is tilted and the coal slides through the chute into the boat alongside.



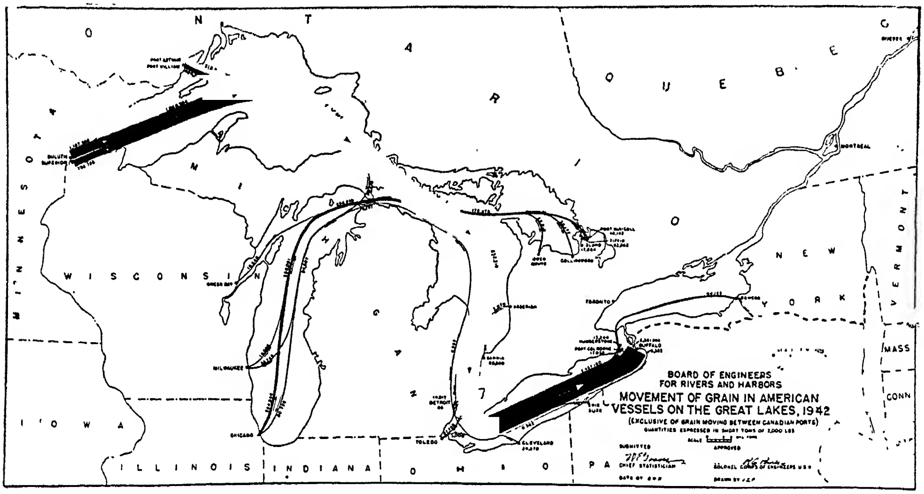
But for the lakes, these stone quarries, which now produce thousands of tons of stone each year, might be picturesque cliffs, or ledges, hidden in a forest.

Marie at the eastern end of Lake Superior often surpasses the combined traffic of the Suez and Panama canals. More than 22,000 vessels pass through the "Soo" canals each year. The tonnage of freight passing Detroit is as great as the combined foreign trade of New York, London, and Liverpool, although it is of far less value per ton.[3] The enormous shipments of iron ore are the largest single item. Shipments of grain, coal and limestone also assume great proportions. In 1940 vessels passing through the Detroit River carried 113 million tons of freight worth more than one billion dollars.

Before the war, millions of tons of coal were carried from the southern shores of Lake Erie to the upper lakes at a freight rate of 40 cents per ton. The ore rate was commonly 70 cents from Duluth to Ashtabula, near Cleveland, and grain was carried nearly 900 miles from Chicago to Buffalo for about 3½ cents per bushel. The lower rate on coal westward was due to the competition of the many vessels for the relatively small return freight. In 1940, 86% of the traffic through the Sault Ste. Marie ("Soo") Canals was eastbound. Important articles in this total of 89.6 million tons were iron ore 66 million tons, wheat 224 million bushels, other grain 63 million bushels, flour 7 million barrels; westbound, 10 million tons bituminous coal and 2½ million tons of other commodities.

The lake steamers are a highly specialized type. They are just as deep as the builders dare make them to pass through the 21-foot channels that have been dredged in the shoals between lakes. The deepening of these passages by the United States Government has aided the shipbuilder in a rapid increase in the size of the boats. The largest lake vessels can hold as much as 572,000 bushels of wheat, 760,000 bushels of

[3] The Welland Canal, connecting Lakes Erie and Ontario, is 25 feet deep, but can be deepened in the future, as its lock sills have a depth of 30 feet. In 1940 the Welland Canal handled 13 million tons of freight, as compared with 90 million tons handled by the "Soo" canals.



The map of the grain movement looks very different from the map of the coal movement. It is mostly through traffic. Note that this is in American vessels only.

oats, or 10,000 tons of iron ore. The capacity tripled in 25 years of channel deepening.

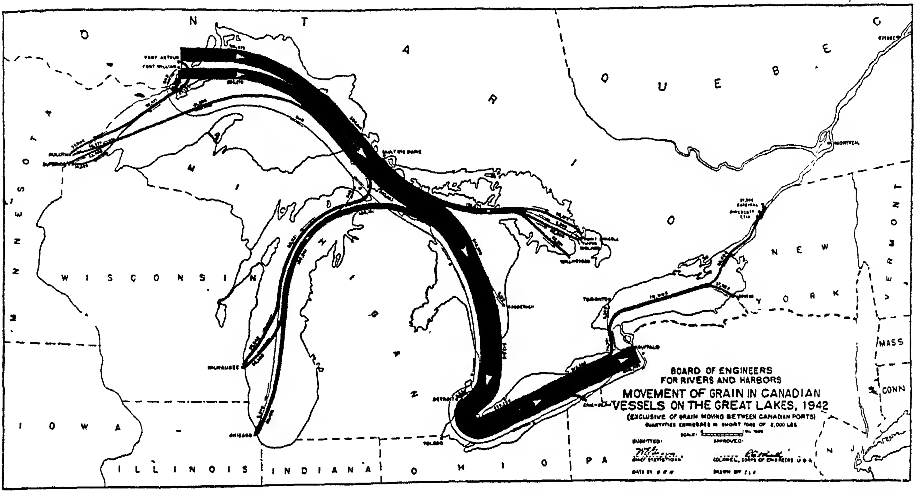
The vessels are built with many hatches for fast loading in which gravity is the chief factor. When the hatch covers are pulled back, the ship resembles an open barge. Iron ore rumbles and thuds into the ship's hold at the rate of 100 tons per minute. Grain pours through elevator spouts at the rate of 2,600 bushels per minute. In unloading the bulk cargoes, especially of ore or coal, clam shell grab buckets, some of them of 15 tons capacity, reach into the bottom of the ship and grasp minerals as human hands would scoop up sugar. To make the voyage of about 950 miles from the head of Lake Superior to Lake Erie ports takes 7 or 8 days, including the time for loading and discharge, and the rapidity with which cargoes are handled is the envy of the entire maritime world.[4] These factors of economy explain why the lakes draw the traffic and why the lake cities have grown.

Eastern Distributors—Canadian Group. From the Great Lakes basin to the Atlantic there are many routes to tidewater between the Gulf of St. Lawrence and the Chesapeake Bay. On the north the St. Lawrence with the port of Montreal offers an economical route to the sea, but unfortunately the present canals around the rapids of the upper St. Lawrence are limited to boats of 14-foot draft, and transshipment from lake carrier to canal boat is necessary.[5] Mon-

[4] Here are some records:

1. The *D. G. Kerr* loaded 12,508 *gross* tons of iron ore in 16½ minutes, 758 gross tons per minute.
2. Above cargo was discharged at destination at rate of 67.6 *gross* tons per minute.
3. The *Wm. G. McGonagle* discharged iron ore at Conneaut—11,445 *gross* tons, or 4,905 *gross* tons per hour.
4. The *Elbert H. Gary* discharged 9,336 *net* tons of coal (bituminous) at Duluth in 6 hours and 5 minutes, or 1,540 *net* tons per hour.
5. The *D. G. Kerr* loaded 13,877 tons of cargo coal and 369 tons of fuel coal in 4 hours and 30 minutes, or 3,166 tons per hour.

[5] In 1940 only 4.8 million tons of freight moved from Lake Ontario through the canals to



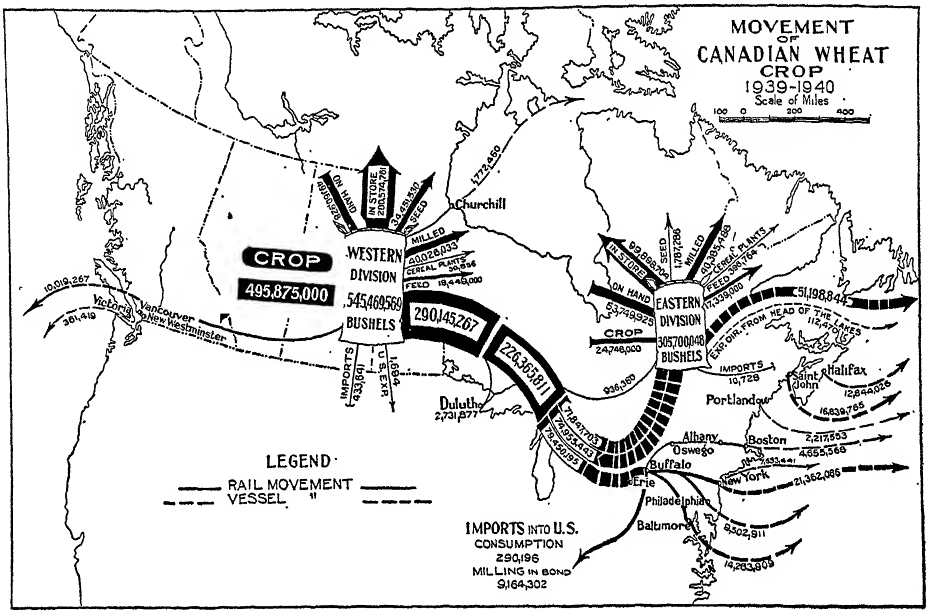
Again grain movement, but this time in Canadian vessels. Those that go to Georgian Bay transfer their cargoes for a short rail haul to the St. Lawrence.

treal is also served by the transcontinental railways running both north and south of Lake Superior. Millions of bushels of yellow grain come by rail or by combined rail and water haul to Montreal's huge elevators, making her the greatest wheat exporting city in North America. Since 1921 there have been various proposals favoring the creation of Great Lakes-St. Lawrence Deep-Sea Waterway, involving the construction of deeper canals around the rapids of the upper St. Lawrence that would permit ocean-going vessels to enter the Great Lakes. Cleveland, Detroit, Chicago, Milwaukee, Duluth, and other lake ports dream of a thriving overseas commerce, but Montreal, Buffalo, and New York oppose the project as they fear the loss of their transshipment trade—scarcity economics.

Unfortunately for a general all-the-year use of the Montreal-St. Lawrence route (400 miles shorter than via New York), the river is closed by ice from December 1 to May 1. Great railroad bridges cross this river at Montreal to give the railways an outlet at ice-free Atlantic ports, chiefly New York, Boston, Halifax, St. John, N. B., and Portland, Me., the latter cities being the chief winter ports for the Montreal steamer lines.

Eastern Distributors—American Group. At the east end of the lakes Buffalo holds a position as traffic distributor corresponding to that of Chicago and Duluth as traffic assemblers. Eastward from Buffalo traffic is shared by a dozen railroad tracks connecting it with Boston, New York, Philadelphia and Baltimore. This multiplicity of roads from Buffalo has been steadily increasing in efficiency, adding new tracks and cutting into the proportion of traffic carried by the now rather neglected Erie

Montreal and other St. Lawrence ports. The canal boats operate as far west as Port Colborne, an important grain storage point at the Lake Erie terminus of the Welland Canal, but the canal boats are almost never seen on the upper lakes.



The movement of Canadian wheat raises some interesting questions such as why should it leave water transport at Buffalo and then go down to Baltimore. Note the insignificance of export by way of Churchill on Hudson Bay.

Canal.[6] The state of New York has spent about $170 million in rebuilding the canal to a 12-foot depth and constructing new locks so that it can carry 1,000-ton barges. The service of the Erie Canal, now known as the Barge Canal, is not to be measured in tons actually carried any more than we measure the value of a policeman by the number of arrests he makes. Every spring for many years the grain rates on the railroads went down when the canal opened, because the canal gave free competition on a cheap highway. Whenever the canal reduced the rate, the railroads had to meet it. Thus the canal has helped to reduce the rate on nearly all the hundreds of millions of tons of freight that have passed from the lakes to the sea—a service of incalculable value. This fact explains the bitter fights that the railroads have so often made to kill the canals.

To the south of the Buffalo routes three other trunk routes of great commercial importance connect the lake shore and the Ohio Valley with the Atlantic ports between Norfolk and New York. The traffic on these east and west routes from the Atlantic coast states to the western plains is the heaviest railroad traffic in the world, and comprises in the main the eastward movement of raw materials and food—grain, flour, lumber, ore, copper, meat, and cattle foods in exchange for the westward-

[6] As late as 1870 rail and canal traffic in the state of New York were about equal, but by 1900 the ratio was 20 to 1 in favor of the railroads. In 1936-40 the average annual movement of freight on the New York State Barge Canal System amounted to 4.8 million tons, as compared with 6.0 million tons in 1866-70. At present the canal system is utilized to less than one-fourth of its capacity.

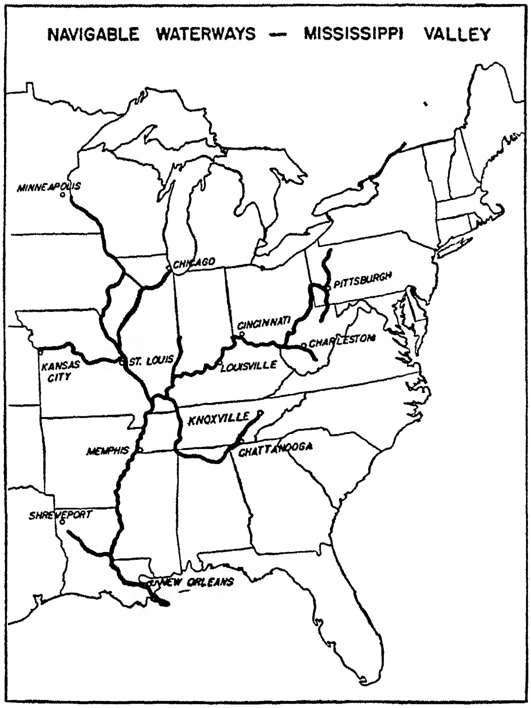
moving manufactured articles and imports in almost infinite variety. The heaviest single item going west is coal, chiefly the superior grades from Pennsylvania and West Virginia.

This rather surprising number of routes to and from the Great Lakes is due to the remarkable topography of the basin of this group of lakes. They lie at the very top of the continental mid-region, *upon its very roof,* a reservoir and water transport system on a level plateau. By the digging of a mere canal at Chicago the waters are diverted to the Mississippi. The four southern lakes are so nearly on a level with the general surface of the country, that they can be approached by railway at almost any point suitable or desirable for the landing of vessels. Hence, the multiplicity of routes to them and from them.

Between the Chesapeake Bay and the Gulf there are no railroads of the first magnitude going inland from the Atlantic, because there is no inducement to take export goods across the mountains to this corner of the continent. The region of the lower Ohio has sufficient natural outlets toward the Chesapeake, the Great Lakes, or the Gulf. Charleston, Savannah, and the lesser South Atlantic ports are fed by the local railways and the navigable rivers in the Atlantic plain. This limitation of hinterland gives them a prospect of permanently small size in comparison to that attained by ports having good connection with the center of the country.

The Side Doors of the Continent. This great sheaf of east and west routes bound together by the Great Lakes, and reaching into the center of the continent, has really included more territory than it can hold. As the result of transitory rather than permanent conditions of settlement, it has, in grasping for the vitals of the continent, overreached and placed itself in unstable equilibrium by taking trade that can, with the improvement of routes, go more easily by the side doors to the south via the Gulf of Mexico.

The Mississippi River with its boats or the possibility of boats has rendered in its field a rate control service almost identical with that of the Erie Canal. The Mississippi Valley with its natural outlet toward the Gulf has created, first, New Orleans on the great river near its mouth, then, newer ports at the sides of the valley. To the west are Houston, Beaumont, and other rapidly growing Texan ports, and to the east are Mobile and Pensacola. Each is located at the ends of promising lines of trade to the upper valley. Each also has a rich local territory in the Cotton Belt. Mobile has, in addition, Alabama iron and coal and the navigable Warrior River, which permits barges from Mobile to come within a few miles of the coal mines. Houston, Beaumont, Port Arthur, Texas City, and Galveston are important raw material ports (see Table 44), shipping large quantities of cotton, petroleum, sulfur, and also Texas, Oklahoma, and Kansas grain. Although the routes to the Gulf ports at present are drawing but little freight from beyond the Ohio and Missouri rivers, their trade is growing and in the course of the coming decades these routes will perhaps be extended to the North, and perform a more important part in our foreign trade particularly with South American and Oriental ports. As the population and industries of the United States grow more like those of Europe, the commerce of the

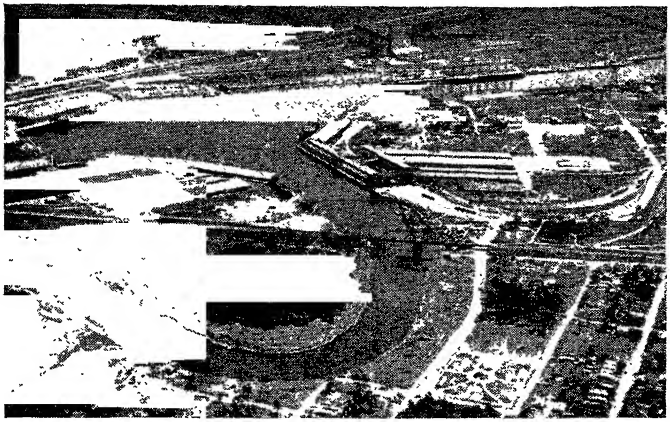


This map of Mississippi Valley waterways helps to explain the reason for a number of cities and shows what vital service the steamboat rendered in the half century after it ascended the Mississippi and before it was eclipsed by the east and west railroads and the traffic by way of the lakes. It did an unexpected and most valuable service during World War II.

Central States will be relatively less with Europe and more with the tropics. The opening of the Panama Canal is another strong factor helping to change the commercial front of the Mississippi Valley from the Atlantic to the Gulf, cotton, sulfur, phosphate, and other commodities being shipped directly to East Asia via the Panama Canal. Furthermore, the South, with rich and varied resources, has made tremendous industrial progress since World War I.[7] As cities and manufacturing continue to grow, the South will be less dependent upon its export of raw materials and will prosper through a better balanced economy.

The development of commerce via Gulf ports does not mean that we shall see any decline for the eastern roads. Under present normal conditions, they are and must be congested, crowded, overburdened with a traffic that results from the great growth of commerce which has come to stay. New trade may go to the Gulf. For example, the wheat

[7] See "The Industrial South," *Fortune*, vol. 10, November, 1938, pp. 44-54, and Almon E. Parkins, *The South: Its Economic-Geographic Development*, John Wiley & Sons, Inc., New York, 1938, pp. 303-505.



The Turning Basin at the inland end of the Houston Ship Canal. You can hardly appreciate the size of this until you fix attention on a couple of ships which are probably about 400 feet long. This waterway, extending for miles through flat country offers great opportunity for industry to spread itself economically over the land. Immediately alongside such factory sites are landing places for ships, power lines, water mains, gas mains, crude oil pipe lines, and master highway, all immediately accessible.

trade of Kansas City is already greater than that of Chicago, and Kansas City is distinctly in Gulf rather than Atlantic territory. For decades American railroads have favored export traffic by granting lower rates on wheat, cotton, and other low-valued, bulky commodities destined for export than on shipments for domestic consumption.[8]

To Europe by Hudson Bay? For years it was felt that a new side door to the continent should be opened up through the construction of a railroad to Hudson Bay, thereby providing a shorter route to Europe for the grain shipments of western Canada. In 1931 the Hudson Bay Railway was completed, connecting the Canadian National Railway System in eastern Saskatchewan with the port of Churchill on Hudson Bay. In spite of the fact that Churchill is about as near to Liverpool as Montreal, and although railway rates on this new route are reasonable, only a minuscule portion of Canadian grain exports move via Churchill (see Fig. 804). Hudson Bay is free of ice less than 3 months of the year.[9] The railroad runs for 510 miles through a wild lake and forest country, and local traffic is nil. There is virtually no inbound traffic. Exports consist solely of grain, but the 5,000,000-bushel elevator at Churchill has never been filled. Both railroad and port facilities were built with government money. In 1940 the

[8] Man-made freight rates are sometimes like tariff barriers. Not until May, 1945, did the Interstate Commerce Commission order a drastic revision of railway rates on high-class freight, eliminating a long-standing discrimination against the movement of southern manufactures to the great markets north of the Ohio and Potomac rivers.

[9] In 1937 only 2 ships called at Churchill for grain. In 1936 there were 14 sailings; the first ship left on August 12, and the last one sailed on October 1. The Churchill winter climate makes it necessary to put a steam heating system in the sewers to keep them open—an interesting example of a geographic factor forcing urban congestion.

railroad's gross earnings from operation were $273,530, as compared with operating expenses of $518,647.[10] More lines like this are not likely to be built! This one was a political football par excellence. Its chief results might be said to be votes and debt.

The Transcontinental Lines. Between the Pacific coast and the more populous East lie the Great Basin, the Rocky Mountain plateau, and the Great Plains, now crossed from east to west by nine railways. They are commonly known as the "transcontinental lines," although, with one exception, they lose their identity at the middle of the Mississippi Valley, which may really be considered their eastern end. They here serve as feeders to the eastern routes described above, which forward the freight from any and all of them to the Atlantic coast points. In the competition for the transcontinental trade, the northern and southern routes are more favorably located than the central; and the most southerly route, the Southern Pacific, has, in some respects, the best location of all, and in other respects the worst.[11] This route, having its termini at San Francisco and Los Angeles in the West, and at Houston, Galveston and New Orleans in the East, has the shortest land carriage, but it has the disadvantage of crossing the most arid part of the United States. Travelers and residents commonly call it desert. From Houston, Galveston, and New Orleans the route is in reality continued to New York by regular lines of steamers operated by the same company. This combination of railways and steamship routes secured much California trade with the East before the opening of the Panama Canal. The northern routes, Canadian National, Canadian Pacific, Great Northern, and Northern Pacific, and the Chicago, Milwaukee and St. Paul have termini on Lake Superior. The Canadian Pacific has steamers from Atlantic tidewater to Europe and from its Pacific termini to the Orient, the Hawaiian Islands, New Zealand, and Australia. The northern routes are also shorter than the lines that cross the central or widest parts of the United States as may be seen by reference to a globe.

The development of transportation facilities across the Great Plains region was rapid. The California gold discoveries fixed American attention on the problem of crossing the plains. The first regular transportation service was the "Pony Express," small packets of letters and valuables carried by relays of galloping horsemen. This was succeeded soon after the gold discoveries of California by wagon trains that set out from St. Louis, Kansas City, and Omaha for New Mexico, Utah, and California. The first of the railways was the Central and Union Pacific, opened in 1869 from Omaha to Ogden and San Francisco. This was built for the transcontinental trade at a time when the buffalo and the Indian still held possession of the plains. It was greatly needed to unite the widely separated East and West and was partly paid for by government money, as people with private capital were unwilling to make the venture,

[10] Dominion Bureau of Statistics, *The Canada Year Book, 1941*, Ottawa, 1941, p. 548.

[11] The Southern Pacific and the Santa Fé are the only railroads that span the country even partially, running as they do from the Pacific to the Gulf of Mexico. The latter follows a more northerly route from Los Angeles across southern California, Arizona, and New Mexico, with one branch extending through Kansas City to Chicago and with another to Houston and Galveston.

predictions of failure being heard on every side. Within seven years Colorado, with its mining camps a thousand miles beyond Chicago in the region served by this new railway, had been settled, organized as a territory and admitted as a state. This state, with its quick prosperity, depended entirely upon the Union Pacific to connect it with the world markets, and was more important to the road than was California with its sea outlet.

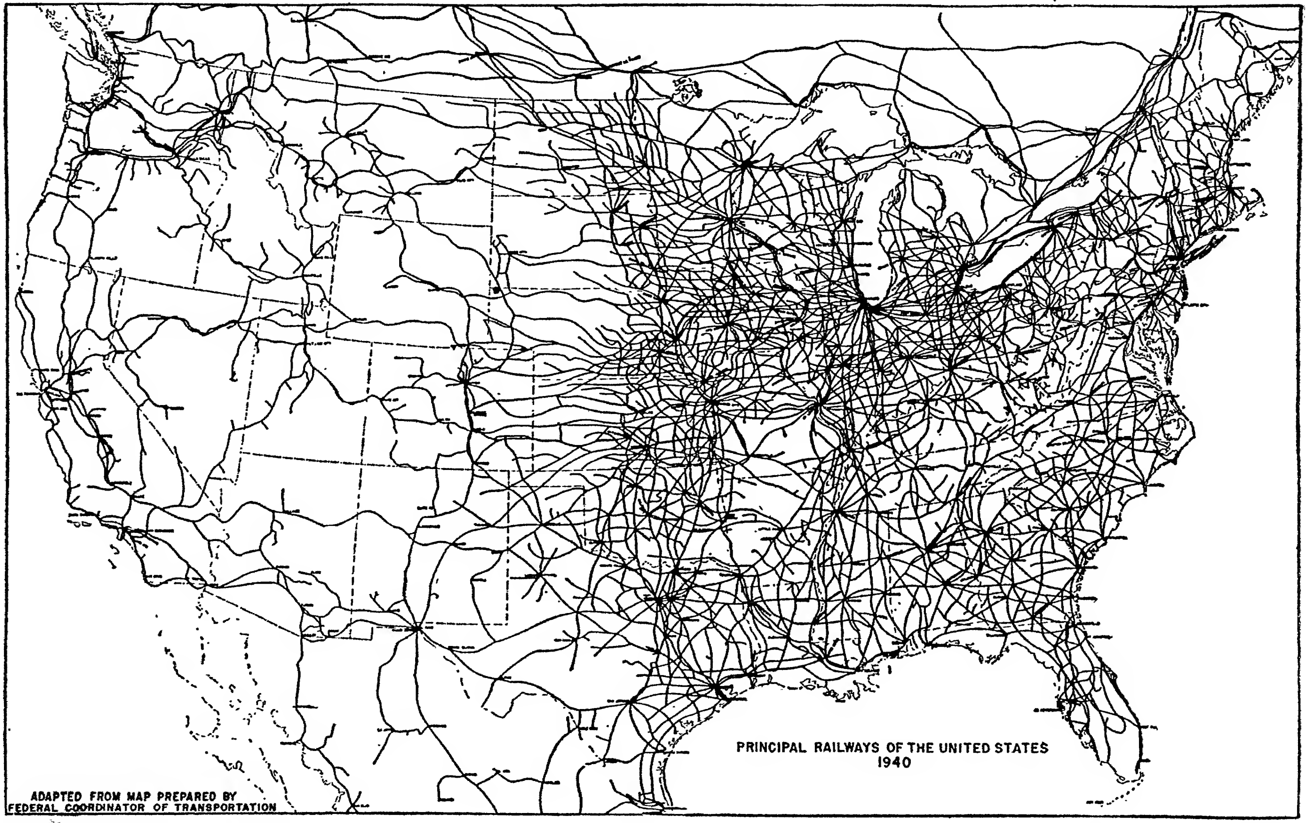
In the United States the three railroads that follow the northern route across the West have the advantage of serving lands of greater humidity. On all three routes, however—northern, central, and southern—there are vast areas cursed by rugged topography and low rainfall. Many railway lines stream boldly across the Great Plains, but only seven pierce the Rocky Mountain barrier and reach the Pacific coast. In view of the low productivity of large areas of the West, the traversing of such "traffic deserts" by 7 major lines speaks eloquently of the rich freights and travel lure of the Pacific coast. Canada is served by two large railway systems, the Canadian Pacific and the Canadian National. Both are transcontinental. The former was completed first (1885); it is owned and operated by private enterprise; and it serves the most populous and productive parts of the Dominion. The latter is an amalgamation of many lines, some of which were private lines that failed, and many of which were built by the Dominion or by provincial governments; its major lines lie to the north of the Canadian Pacific and serve a less productive territory; and this government-owned system has never been profitable.

At their eastern and western extremities, the transcontinental lines enter lands of denser population and greater productivity. East of the Rockies, and particularly east of the Great Plains, these through lines must compete with many railroads for the large eastbound traffic in cattle, sheep, wheat, corn, hogs, and cotton. West of the Cascades and Sierra Nevada the transcontinental lines help to serve a considerable local traffic, but along the Pacific coast they meet the competition of coastwise steamers. Of the total transcontinental traffic, approximately 65% is eastbound and 35% westbound. On all three sections westbound traffic consists chiefly of iron and steel manufactures, automobiles, farm machinery, and many other manufactures.

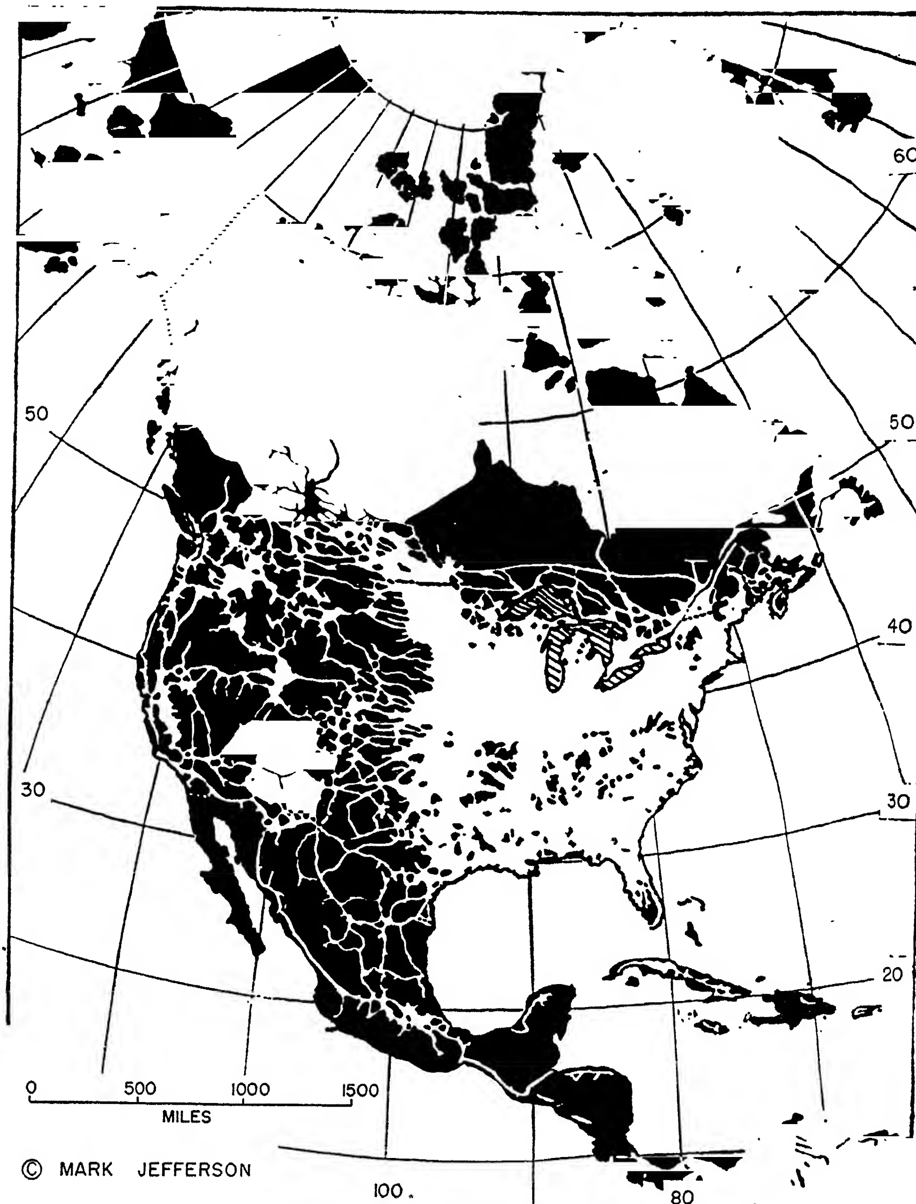
On the northern section eastbound traffic includes raw silk, tea, and other Oriental products entering the country through Puget Sound ports, deciduous fruit from the Northwest, and various agricultural, pastoral, and mineral products from the interior, but the largest item of freight is lumber which moves by the trainload from the Pacific Northwest to the great markets of the East.

On the central section the railroads carry apples and other deciduous fruit from the Northwest, fresh and canned fruit and vegetables from central California, dried fruit from California and Arizona, beet sugar from California, Utah, and Colorado, and livestock and minerals from scattered localities.

The people of the mid-region of the transcontinental railroads are great traffic producers. They are almost exclusively engaged in agriculture, mining, or lumbering. They are far from their markets and their sources of supplies. They sell much and they buy much, so



This map of the railway net of the United States might also be called a map of the Great Open Spaces. You can check your geography by asking yourself why each concentration of railway lines and why each vacant space.



Every railway line is shown 20 miles wide; therefore, all land more than ten miles from a railway is black. This map was originally made by Mark Jefferson in 1926 and as nearly as possible brought down to date with railroads until 1940. Does any other single map tell so much about the economic geography of a continent? If we could have alongside of it a population density map and a rainfall map, you'd have an interesting story for those who could read maps.

that a single farmer's family in the region of the Great Plains is reckoned by some railroads as contributing $500 a year income to the company. This explains their diligent labors to get settlers on their lines.

On the southern section the railroads carry minerals and pastoral products from the interior and much produce from the great irrigation projects of the Southwest, including citrus fruit, dried fruit, cantaloupes, beet sugar, beans, lettuce, and long-staple cotton. The ocean trade of Los Angeles has grown like a mushroom since 1910, the largest share of it being with the Gulf and Atlantic coasts (see Table 44).

In the northwest the chief productive regions (aside from lumbering) are the Columbia and Willamette Valleys. which also furnish routes for railways to Portland, Seattle, and Vancouver. The Columbia is also navigable to the eastern boundary of the state of Washington. The great excellence of Puget Sound for the development of good harbors and ports, combined with the richness of its immediately adjacent territory, and the shorter route to a rich interior, marks it as a site, perhaps *the site* of the coming commercial and industrial metropolis of the Pacific coast of all America.

The nearness of the Pacific coast population to the ocean causes the Panama Canal to be easily effective in stimulating trade, which with its raw products, is so dependent upon the markets of populous regions.

Between Vancouver in southern British Columbia and the Yukon Valley is a mountainous region with unclimbed peaks and valleys unthreaded by world or local commerce. In latitude 54° 20′ near the southern point of Alaska where the Skeena River flows from a defile in this mountain mass, one transcontinental railroad, the Canadian National, reaches the Pacific at the lonely little town of Prince Rupert, on a coast so steep that there is scarce room for a town of 6,000 people. Beyond this, in Alaska, the Arctic interior of the continent was served for many years mainly by the Yukon steamer in summer, the dog sled and the human pack-carrier in winter. The Klondike gold fields lying upon the upper Yukon on both sides of the Alaska-Canadian boundary were at first reached by the trail over the mountains near the coast of south Alaska where a short but fearful journey separated sea and river navigation. Within two years after the important gold discovery on the Klondike (1897), a railway, beginning at the harbor of Skagway, had crossed the mountain pass and connected the steamer on the fiorded coast of south Alaska with the brave stern-wheel steamers that risk the shifting sands of the Yukon. But this river is open only in the summer months and must be *entered* from St. Michael, across a part of the Bering Sea. The lower river route to the Klondike is hundreds of miles longer than the more direct one over the mountain ranges that separate the upper Yukon from the Pacific. The Alaska Railroad, built and operated by the United States Government, now connects Seward with Fairbanks, nearly 500 miles north on the central Yukon.

The possibilities of travel in the interior of Alaska are being greatly improved by the use of the airplane, which can carry not only passengers but surprising amounts of mining machinery

and other heavy freight. Land transportation is aided by the domesticated reindeer, which has been introduced by the aid of the government. This work animal is perfectly adjusted to North Alaskan environment where it can also furnish meat and milk. It is a great aid to prospectors and miners in the search for minerals in which Alaska and northern Canada seem to be promising.

Seattle and San Francisco are the chief trade bases for the vessels which carry almost the entire trade of Alaska. Alaska sends gold and copper, fish (mostly salmon), and furs in exchange for the great list of foods, clothing, and supplies needed by white men in a cold land not well suited to agriculture.

3. Mexico and Central America

The Trade Routes of Mexico. The trade routes of Mexico are, in part, a continuation of those of the southwestern part of the United States. The great majority of the Mexican people live upon the plateau enclosed by the eastern and western Cordilleras that nearly parallel the two coasts until they meet a short distance south of the city of Mexico. Two main railway lines from the United States enter this plateau by the easy northern ascent. These are the National of Mexico, an extension of the Santa Fé from El Paso through the Central Plateau to Mexico City with numerous side lines, and the eastern division of the same connecting at Laredo with the International and Great Northern. Two other lines, from Tampico and Veracruz, climb the steep escarpment from the Gulf Coast. The northern routes carry an active overland trade with New Orleans, St. Louis, Kansas City, and Chicago; but a larger and more valuable trade goes to the Atlantic ports of the United States and Europe by steamers from Tampico and Veracruz. The imports comprise the great variety of supplies and machinery used in a mining and ranch country that until recently had little manufacturing of the factory type.[12]

There is an isolated railway system on the flat plains of Yucatan. Three small lines, converging at Progreso, serve to collect the Yucatan sisal crop for shipment from that port.

The Pacific coast of Mexico is inadequately supplied with trade routes, many of the smaller ports having only mule trails to mines in the interior. The trade of that region is naturally with the Atlantic, from which it is profoundly barred, as the western Cordillera is high and abrupt, making railroad building difficult. A number of lines have been projected, but the only one completed was in 1902 when the trains first crept down from Guadalajara, on the plateau, to the port of Manzanillo, the completion of this line permitting through traffic to Mexico City. Since that time an American company, the Kansas City, Mexico & Orient, has started to build a line from Kansas City through El Paso to Topolobampo, a port near the lower end of the Gulf of California. This line now extends southward as far as El Salto, Durango, but has never been completed to Mazatlán, the proposed terminus on the coast.

A number of years ago a branch of

[12] See M. Ogden Phillips, "Manufacturing in the Federal District, Mexico," *Econ. Geog.*, vol. 9, July, 1933, pp. 279-291.

Transport south of the Rio Grande. With a few variations in detail here and there, this might be almost any part of Mexico, Central America, the West Indies. It happens to have been taken in the Virgin Islands, where a group of small farmers are on their way to market with produce on donkeys, in their hands, on their heads. The West Indian head is really a very important vehicle of transport. It has been said that a head was a place to keep your hat, but in the West Indies, it is a place on which to carry your basket.

the Southern Pacific was built south from Tucson, Ariz., to Guaymas on the Gulf of California. Beginning in 1905 it was pushed southward along the Gulf through Mazatlán to Tepic and the little port of San Blas. Eventually, after many delays, another railroad was built northward from Guadalajara to Tepic. The completion of this line now gives Mexico City direct railway connection with the west coast states of Sinaloa and Sonora, and it provides a third main line from the United States to the plateau.

Mexico has, in the Tehuantepec Railway, a short transcontinental line connecting Puerto Mexico on the Gulf with Salina Cruz on the Pacific. This road was built by the Mexican Government in 1907 on one of the routes once cherished as a site for an Isthmian Canal. Prior to the opening of the Panama Canal this railroad handled a little interoceanic traffic, but today its chief items of freight are northbound bananas and coffee that are shipped from Chiapas to Puerto Mexico for export.

The Central American Routes. With the possible exception of western Mexico, Central America is the most unfavorable part of the North American continent for the development of trade routes. It is in the zone of tropic rains, tropic forest, and low, malarial coasts. Nature puts such difficulties in the way of man that no explorer has ever traversed the whole length of Central America's eastern plain. The unwholesome climate of the lowlands has caused Central American population to seek the plateau along and between the double mountain range that makes the continental divide. It so happens that this plateau is much nearer the Pacific than the Atlantic; some of it was settled from that ocean, and at the end of the nine-

teenth century all the capitals of Central America, with one exception, had their connection with the outside world by way of the Pacific, in spite of the isolation of that coast. This isolation has been greatly modified by the coasting steamers that since 1848 have plied between Panama and San Francisco. Guatemala City is now linked by rail with Puerto Barrios on the Caribbean. It is also possible to go by rail from El Salvador to Mexico City. The other capitals have railways to one ocean or the other, except Tegucigalpa, in Honduras, which has a first-class motor highway leading to the Gulf of Fonseca upon the Pacific. Central Nicaragua also has a partial outlet to the east by the steamers, which at some seasons navigate the San Juan River from Lake Nicaragua to the sea at Greytown. Other Central American railways are in contemplation or building. In considering the Central American trade routes and their prospective development, it must be remembered that the population of each of the political divisions consists of a few thousand white people of Spanish race and a few hundred thousand Indians, many of whom are more or less tinctured with white blood.

The Panama Canal and the Trade Routes of North America. The opening of the Panama Canal between the Caribbean and the Pacific has caused a number of commercial readjustments and affected many of the trade routes of the continent. The changes in traffic movement, however, are not so much in traffic actually diverted from one route to another as in new traffic that has resulted from increasing industry. As time goes on, the routes from the northern Mississippi Valley eastward will decline in relative importance, while those to the Gulf increase. The routes from the continental divide westward will be stimulated by the increase of local traffic that must be called into existence by a cheaper ocean rate to the Atlantic.[13] This will be quite as true in Central America and Mexico as in Canada and the United States. The same force that increases the traffic of existing railways from the Pacific coast to nearby points will cause the construction of other lines, furnishing routes for traffic that does not yet exist.

These advantages of the canal to the railroads will continue to develop with the passage of time; the first result was the loss of some through trade by the transcontinental lines. Our railways have changed their scheme of things to an arrangement whereby they gather the commodities within a continent's interior and lay down the assembled bulk at the nearest port, be it Atlantic, Pacific, Lakes, or Gulf, to be forwarded by water to its ultimate destination.

[13] A short haul to the sea and a cheap haul through the Panama Canal to Europe has made the port of Vancouver a recent big shipper of wheat from the Prairie Provinces of Canada. (See Fig. 804).

. . . 27

The Trade and Trade Routes of Europe

1. Europe's Unusual Advantages for Trade

The trade of the different European countries with each other is of great extent and closely resembles the trade of temperate North America. Each of these continents has, in the region of middle temperature facing the Atlantic, a large territory with tens of millions of manufacturing people buying food and raw materials. In America this manufacturing region may be said to be bounded by a line connecting St. Louis, Milwaukee, Montreal, Portland, Maine and Baltimore, and extending back to St. Louis. In Europe the manufacturing belt extends from Stockholm, Budapest, and Florence westward to the ocean, including Great Britain, the birthplace of the modern factory system. Farther in the interior of Europe and America lie the grain- and meat-producing plains; in the north are water power and forests with their wood and paper output; in the south, the land of fruits and early vegetables. Europe has only a small corn belt and almost no vestige of a cotton belt, but has instead a great extent of potato, barley, oats, and rye belts in her mid-region.

In the natural ease of her exchange of these foods and raw materials for manufactures, Europe has been favored more than North America, more than any other continent. Irregular coast lines make short and easy communications between the interior and the sea—the cheapest of all highways. Here Europe is supreme. Africa and South America resemble solid blocks; and even the United States, with its favorable location, its splendid routes, and an area nearly equal to that of Europe, has but 5,200 miles of seacoast, while Europe has 20,000. Hence, it is natural that the greatest trade routes of Europe should be water routes, and that its railway mileage should be relatively low.

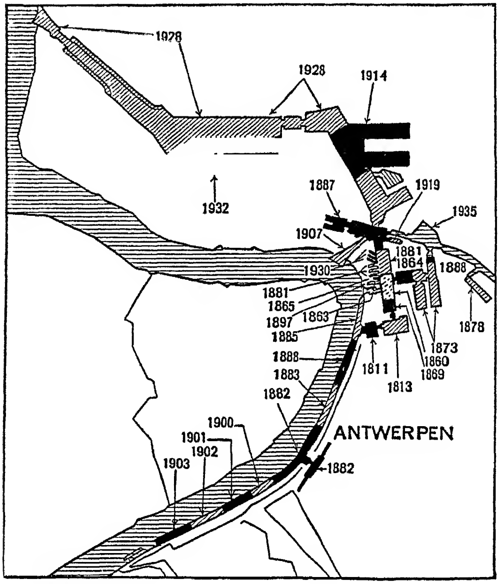
Trade is further favored by the location of the inland seas that indent the European coast. In the north, as in the south, a succession of seas penetrates to the very center of the continent and beyond. The only comparison would be the American Great Lakes and the Gulf of Mexico if they reached farther inland and were navigable at all times by ocean vessels. The Mediterranean and the Black Sea extend the advantage of the ocean 50° eastward from western Spain. This may properly be called the most magnificent system of inland waterways in the world. Its waters give ocean transport to a dozen independent countries and many colonies. Through the navigable rivers of south Russia and the great Danube, it reaches far into the

rivers of third-rate importance, the Ebro and the Po, in addition to the second-class Rhone. The Po is practically choked with mud at its mouth—a condition which is usually found in rivers flowing into tideless seas, such as the Mediterranean.

The mountain wall of the Alps shuts the Mediterranean away from the waters of the land, but the low shores of the Black Sea permit that body of water to drain much more than its proportional share of Europe. It receives the Danube, a river draining with water and boats the very center of Europe, and navigable throughout most of its length. In recent years it has been made an international highway; and a canal, that has been cut through its swampy delta, avoids the dangers of its multitude of broad and shallow mouths, and permits the entrance of ocean-going steamers, which ascend to the Rumanian ports of Braila and Galati, there to take the grain cargoes that have come down in barges through the Iron Gate from the plains of Hungary. A more direct route for this important traffic, which is often bound for the lower Rhine Valley, would be directly upstream and overland or through shallow canals, but the cost of land or small-barge transportation is too great in comparison with the river-sea combination over a much greater distance.

The Black Sea traffic is further enriched by the steamers on the Dniester, the Dnieper, and the Don rivers, and by the south Russian railways. In times of normal trade these help to assemble the Russian wheat and corn at the ports of Odessa, Kherson, Nikolaev, Taganrog, and Rostov, where the tramp steamers call for grain. Within the Mediterranean there is traffic between two distinct economic districts—a food-importing district and a food-exporting district. While Italy, France, and Spain are chiefly agricultural countries, they are also manufacturing countries and must import to some extent both food and raw materials. The east Mediterranean region, comprising the Balkan states, the Danubian states, Russia, Asia Minor, and the Caucasus, is essentially in the raw-material and food-producing stage. Grain and other agricultural products are the chief exports, and to these, the east end of the Black Sea with ports at Poti and Batum adds ores and petroleum exports. This gives the basis for a lively exchange of manufactures from the west for the wheat, corn, rye, and oil of the east Mediterranean.

The Great Northern Route. The Baltic waterway, terminating at Leningrad and Oulu, is favored by receiving more navigable rivers than its southern counterpart. Two of these are the Rhine and the Elbe Rivers, which must be classed as of the first magnitude if measured by the commerce that they carry. The Elbe carries down to Hamburg the products of central Germany and of Czechoslovakia. It is also connected with the Danube by canals. The Rhine has with great labor and expense been made and kept navigable from the dykes of Holland to the waterfalls of Switzerland. Other contributions of freight to the western and northern seas are supplied by the Tagus, the Garonne, the Loire, the Seine, the Weser, the Oder, the Vistula, the Niemen, and the Duna, as well as the canals which thread the plain of north Europe from the west of France to central Russia. The gentle



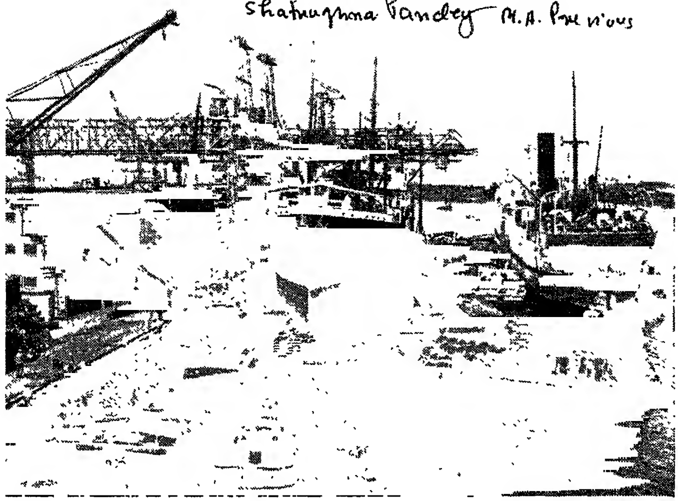
The river Scheldt and harbor works of the city of Antwerp, with the dates of construction of various parts. Owing to the high tide most of the docks are behind locks, which hold the water at high tide level. Ships can enter these locks only near high tide. In the extreme northwest corner of the map is a lock admitting to a large area. There is another at the place marked 1907, and still another at 1811. It is not difficult work to dig such docks in the soft alluvium—it is more trouble to make solid foundations.

topography and easy drainage of north central Europe thus give many avenues to the sea, and make possible east-west waterways, especially in Germany, that duplicate to some extent the service of our Great Lakes.

Especial emphasis should be laid upon the valleys of the Elbe, the Rhine, and the Seine. The Rhone Valley, also reaching the center of France, is like them. Each contains a navigable river with two lines of railway following it. Each has at least one great commercial city at its mouth—Marseilles by the Rhone, Le Havre by the Seine, Hamburg by the Elbe, and Antwerp, Rotterdam, and Amsterdam, all reached by boats on the distributaries of the Rhine. These last are the termini of the greatest of all the inland European trade routes, because the Rhine Valley is the greatest industrial region on the continent, and has the most efficient and extensive river transportation in addition to the busy railroads.

The northern route is bifurcated, the lesser branch passing out in the open sea around the coast of Norway and into the White Sea, which, despite its Arctic location, has in its port of Archangel a heavy shipper of lumber and grain and in Murmansk, a port that is open all the year, thanks to the last reaches of the Gulf Stream. The ports

Shatrughna Pandey M.A. Previous



This scene in the harbor of Rotterdam typifies much of the commerce of northwestern Europe. Canal boats and barges cluster around the ocean steamers, receiving cargo directly overside to go hither and yon upstream and through canals of Netherlands, Belgium, France and Germany. At the left we see a three-story warehouse with portico in front of second and third stories, permitting the cranes to swing goods from barge to warehouse door. A veritable forest of cranes is visible. The wall at the edge of the water rests on pilings, which are never exposed to the air. We happened to be present at a removal of a pile put down in 1386. When a bit was chipped off, it looked so fresh that it appeared to have been in the mud only for a season. Wood rarely decays under water.

of Norway add their contingent of lumber, as well as iron ore, fish, and granite.

The Work of the Heavy Traffic Routes. The heavy traffic routes of European commerce, skirting the continent and fed by the secondary routes enumerated above, are served by a multitude of coasting vessels, large and small, giving access to every port of Europe and to every country except to Switzerland, Czechoslovakia, Austria, and Hungary; Switzerland has Rhine boats, Czechoslovakia has Elbe and Danube boats, and Austria and Hungary have Danube boats. It is by ship that the heavy freight of Europe is carried, the traffic in which economy of cost is more important than economy of time—the wines, fruits, and oil of Spain, France, and Italy; sulfur from Sicily; dried fruits from Greece; wool and figs from Turkey; grain from Hungary and the Black Sea; manganese from the Ukraine; petroleum from the Caucasus; sugar from Czechoslovakia; wool from Scandinavia and Finland; grain from Baltic Russia; British coal; Belgian cement, glass, and iron; and the machinery and the heavy manufactures of Great Britain, Germany, Belgium, and France.

The manufacturing region of Europe is either the origin or destination of most of this water-borne commerce. It is a region threaded by canals and navigable rivers giving to every capital except Berne and to almost every manufacturing city of importance the ad-

vantage of barge transportation to and from the seaports, thus affording very cheap rates on such industrial fundamentals as coal, iron, wood, stone, ore, cement, cotton, grain, and heavy manufactures. The efficiency, the importance, and the function of the heavy traffic routes are better shown by some of the more extreme cases. Regular lines of steamers carry freight from Hamburg and Rotterdam to Mediterranean and Black Sea ports. On the quays in Antwerp one may see iron bridges that have come by Rhine boat from Düsseldorf, en route to Rumania by the next Black Sea steamer. There are even lines plying between such extreme points as Istanbul and Odessa in the south and Leningrad in the north.

Utilization of Transport Resources. The manufacturing region of northwestern Europe has the most fully developed transport system in the world. It is a labyrinth of canals and the rivers have been improved at great expense. In an area of 800,000 square miles more than a billion dollars have been expended in waterways. This, however, is the trifling sum of $2 per acre, and it has paid many times over in the increased ease and cheapness of commerce.

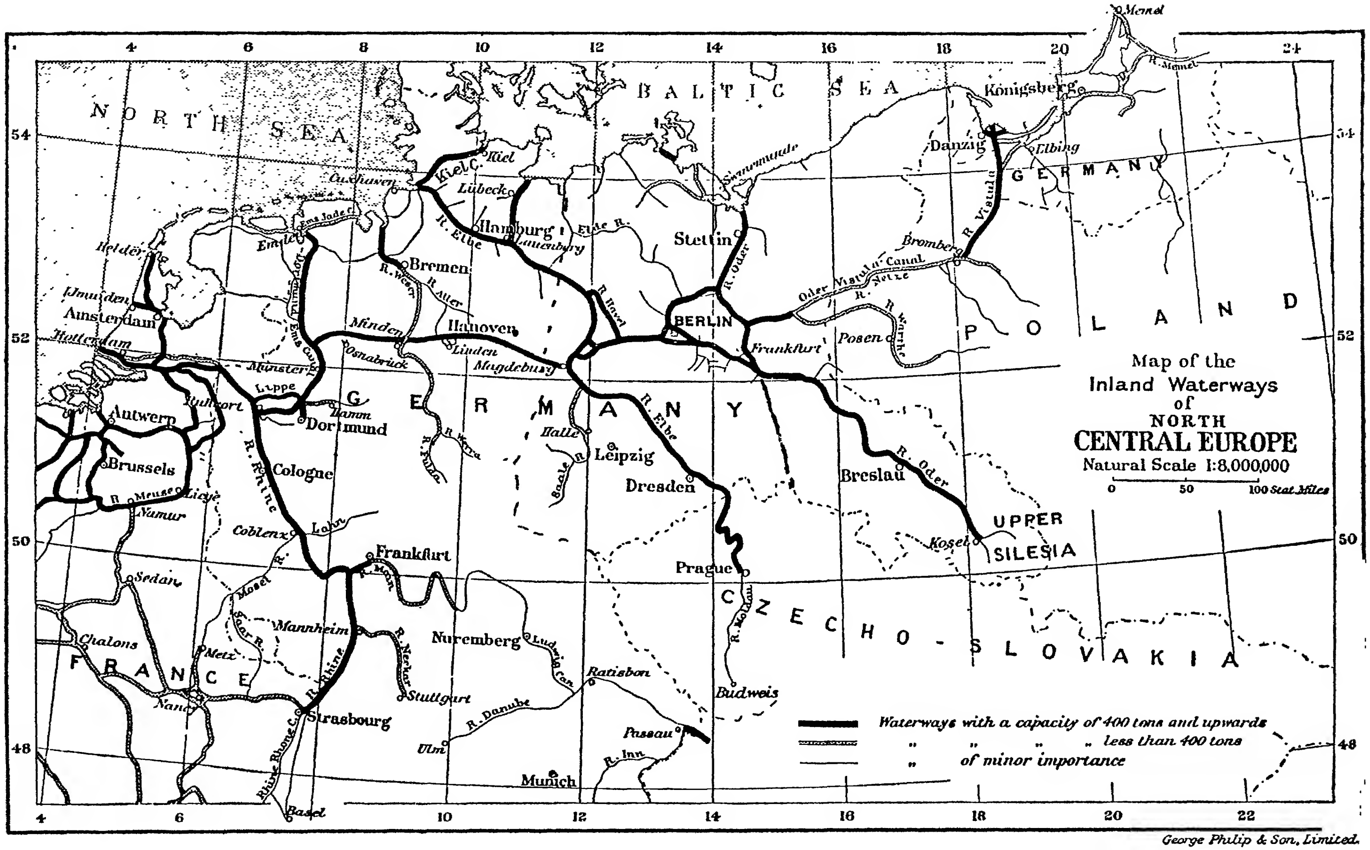
The results of deliberate effort are shown by the upper Rhine navigation. In 1893 this river was navigable only seventy days between Mannheim and Strassburg, but owing to the deepening and care of the river, the Rhine today is open to navigation throughout nearly all of the year.[1] Few people realize the enormous volume of traffic that the Rhine normally carries, the prewar traffic having been about 60 to 70 million tons of freight yearly. In 1937 Germany had an inland waterway fleet of 17,757 craft which carried 133 million tons of freight, or about 27% as much traffic as was handled by the efficient German railway system.[2] Prior to World War II, Russia had 68,000 miles of navigable waterways; Germany, 7,000; France, 6,100; Holland, 4,800; Great Britain, 4,000; Poland, 3,800; Sweden, 3,100; and Belgium 1,000.

The efficiency of Europe's water routes and the important part that they perform in her commerce is shown by the comparatively small railway mileage. Europe and Asiatic Russia have only about 20,000 miles more railway than the United States, but the population is nearly four times as great and the area about twice as great. The railways are not so necessary where there is such a wealth of waterways so well utilized as those of Europe. Europe has no such problem as that presented by the transportation to the sea of the vast traffic that seeks an outlet from the American Great Lakes. If she had, her railway mileage would be much greater. Conversely it is easy to see that the access of ocean steamers to the Great Lakes at all times might remove the necessity of thousands of miles of railway track. The great railway mileage of America is a record of achievement, but also an admission of the handicap of excessive space and a poorer shape for easy transport.

While Europe far exceeds North

[1] On the average, navigation is affected adversely only 8 days of the year by high water, 17 days by low water chiefly along the upper Rhine, and 17 days by ice.—See Edna E. Eisen, "The Structure of Rhine Traffic," *Econ. Geog.*, vol. 10, July, 1934, pp. 254, 266.

[2] In comparison, the rivers of the United States handled 156 million tons of freight in 1937, and 149 million tons of cargo were shipped out of American ports on the Great Lakes.



Only two places in the world, namely China and northwest Europe, have such a system of waterways with cross connections. We would have a duplicate if we had canals from Lake Erie to the Chesapeake Bay and from Norfolk to the Tennessee River. The Chicago Drainage Canal furnishes vital connection in this system.

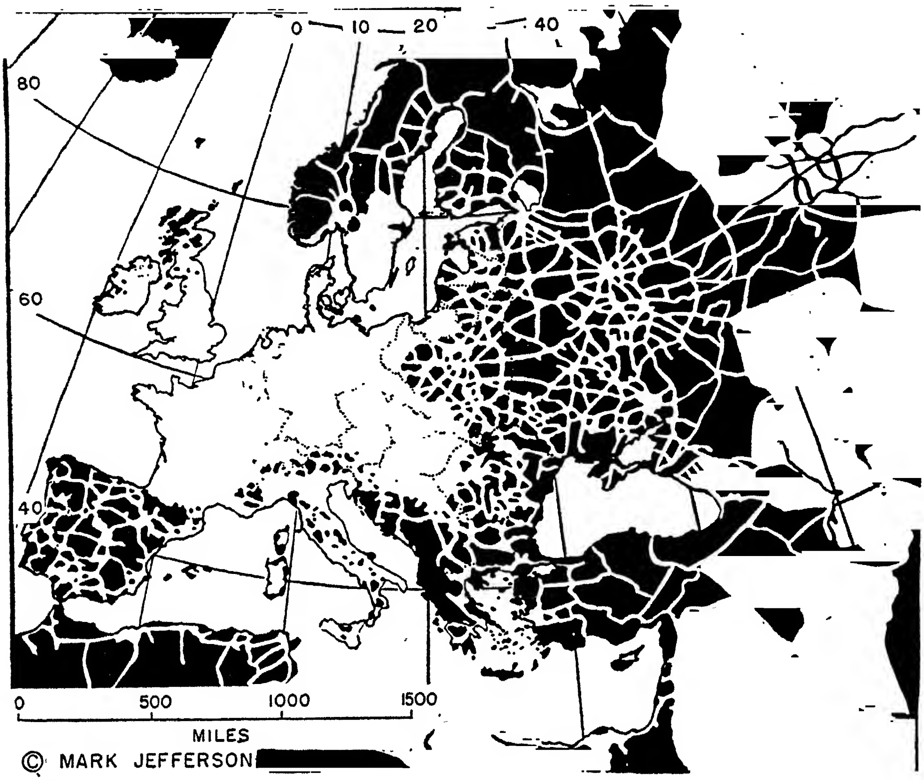
America in the utilization of waterways, its railways have not attained the same superiority. The many independent states of Europe form a bar to such a thorough organization of railway traffic as exists in the United States, where uniform regulations exist over wide areas, enabling the railroads to perform wonders in transportation that have not been duplicated elsewhere.[3]

The Volga and the Caspian. In the class with the great water routes of west Europe is the Russian inland system comprising the Caspian Sea and the Volga River. In its upper course the Volga is linked by canal with Lake Ladoga and the Leningrad industrial area along the Gulf of Finland, and in 1937 the completion of the Moscow-Volga Canal opened a new route for barges drawing 8½ feet of water. The Volga-Caspian waterway is the nearest European counterpart to the American Great Lakes. It fully equals it in length, but the commerce is by no means so vast, even though the river and the sea stretch from the heart of Russia and Russian industry into the confines of Asia, and offer an excellent avenue for the heavy trade that arises in districts with heavy products and with reciprocal needs. In the northern part of the Volga's course its navigable western branches drain the manufacturing and commercial regions of Moscow and Gorki. The northeastern branches come down from the lumber regions. The main course of the river traverses a grain-producing and, in its lower courses, a pastoral region. On the Caspian, an important petroleum district lies at the point where the Caucasus Mountains project into the sea. There are fisheries in the Caspian, and fish and petroleum are shipped upstream in exchange for lumber, grain, and manufactures. All these, however, do not make bulk to match the iron ore of the American Great Lakes. Unfortunately, at the delta port of Astrakhan the Volga is closed by ice 101 days of the year, while the grain port of Rybinsk on the upper Volga is closed 146 days each year.

3. *The Overland Routes of Europe*

The Fast Traffic on Overland Routes. The water routes that surround western and central Europe afford an excellent basis for the heavy commerce upon which industry rests. But these cheap and therefore important routes are slow, and in a region so populous and so advanced in industry there is a large traffic that requires the most expeditious routes —the railroads. Passengers, mail, and valuable or urgent freight use these routes. For through traffic of this character, there is a well-organized system of railway trunk lines performing a service which is quite distinct from that of the heavy system with its feeders. The fast traffic routes connect the great centers of population, and the quickest time is therefore often made over somewhat circuitous routes that happen to

[3] The actual freight service rendered by a nation's railroads is more clearly revealed by the total number of ton-miles than by the total number of tons of freight. A ton-mile represents the transportation of 1 ton of freight for the distance of 1 mile. In 1937 the amount of freight service, in billions of metric ton-miles, was as follows: United States, 347; Russia, 220; Germany, 50; Canada, 24; France, 23; India, 21; Great Britain, 18; Poland, 14; Japan, 10. In 1943 the amount of freight service performed by American railroads was more than double that of 1937.

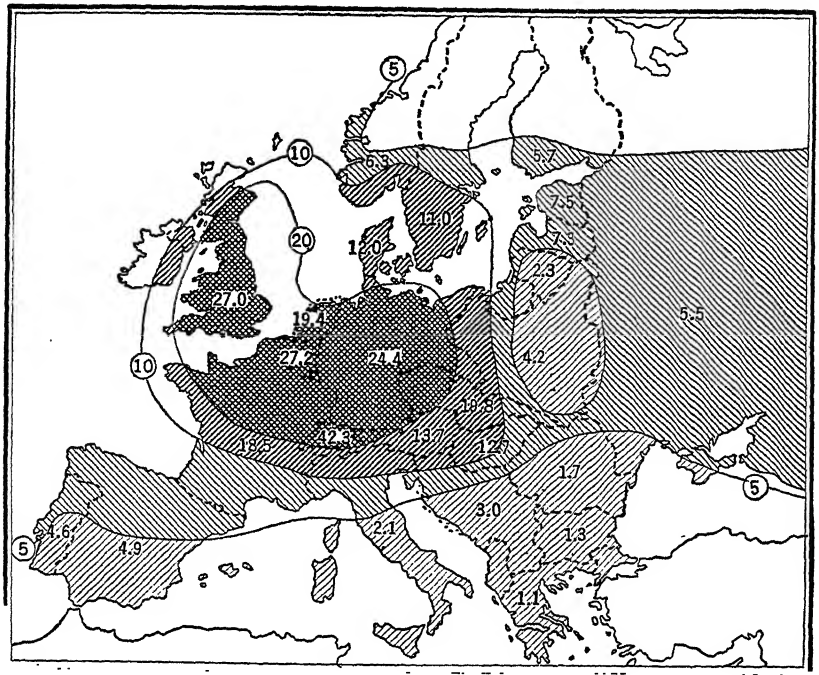


Despite the completeness of enveloping water routes, west Europe has enough people to have developed a very complete railway net.

pass a number of large cities. The configuration of the country sometimes helps population centers to locate the fast traffic routes of Europe with some disregard of distances.

Paris and London as Railway Centers. Paris is probably the greatest railway center of Europe, but London may properly be taken as the starting-point for the fast railway service that connects all the capitals of central and western Europe. The British capital is the starting-point for an enormous mail and passenger movement. The city is the center of the British railway system, having direct and very fast connections with Edinburgh, Glasgow, Liverpool, and Cardiff, and a fast mail route to Ireland. A link in the mail route is the Irish Sea steamer service, in which fast merchant steamers ply between Dublin, Ireland, and Holyhead on the Island of Anglesea, off the coast of north Wales.

There are several routes from London to the continent with quick and frequent service, and the time tables of continental railways advertise the London connections with their lines. The continental routes spread out to the south and east of London like a fan. Paris is reached by a combination of railway and channel steamer, over four routes: Southampton-Havre, Newhaven-Dieppe, Folkestone-Boulogne, or



This map of railway journeys per capita per year agrees very closely with the Jefferson railway net map.

Dover-Calais, the last being the most used.[4] From Paris the southwestern route passes Bordeaux and Madrid and ends at Lisbon. Another line runs southeast from Paris and divides north of Lyons, one branch going down the Rhone Valley to Lyons and Marseilles; the other, going southeastward, passes through Mt. Cenis tunnel to Turin, Genoa, Leghorn, Rome, and Naples. This is the usual route for passengers between London, Paris, and Rome. A route nearly parallel to this is the Oriental mail route from London via Harwich-Flushing (steamer), the Rhine Valley, Basle, the St. Gothard tunnel, Milan, and Bologna to Brindisi. The Oriental mail thus leaves London several days later than the steamer which finally gets it at Brindisi.

The region lying between Vienna and London is populous, highly industrial, and so well covered with a network of railways that it is possible to traverse it in many directions. Several regularly followed routes connect the British and Austrian capitals. The Danube Valley is usually entered from the Elbe Valley by way of Dresden or Berlin, or from Frankfort or Strassburg in the Rhine Valley. From Vienna this southeastern route extends, with regular express train service, to Budapest, Belgrade, Sofia, and Istanbul. A branch of this route runs from near Belgrade to Salonika and Athens, making the Greek seaport

[4] Only British conservatism and fear of invasion prevent the construction of a submarine railway tunnel below the stormy Straits of Dover, and it was not until 1936 that regular ferry service for passenger trains was established between England and France.

of Piraeus another port for the Oriental mail.

The last of the routes starting from London goes to Berlin by way of the Rhine mouth ports and Hanover, and it also extends to Warsaw and Leningrad. It is the mail route from Russia, and to some extent for Germany also, to Britain, and America, because the train is faster than the ship, and this rail route makes its final connection with steamers at Southampton or Cherbourg.

The Trade Routes of Russia. There is across Europe one east and west route of much importance and greater promise—that of the Asiatic express. Although it might be said to begin at Madrid or Lisbon, Paris is the real beginning and the place from which the Russian and Asiatic express trains start. At Warsaw the route divides, the northern arm going to Leningrad, the southern to Moscow, eastern Russia, Siberia, and China. This is the route of promise. The heavy mail from west Europe to the Orient is to be reckoned as the first capture of the trans-Siberian Railway from the slower circumcontinental steamers. As the vast and fertile plain of Siberia is settled, developed and industrialized, the chief avenue of its economic and intellectual life will be along the railway running east from Moscow, and this trade route will in all probability continue to outstrip all other Eurasian trade routes in the rate of increase in its traffic. This is the more certain because this route differs from all others in that there is little water competition for the larger part of its territory. In 1938 the northward-flowing Ob, Yenisei, and Lena rivers handled about one-fourteenth of Russian inland waterway traffic.[5] With the aid of icebreakers, a dozen or more steamers make the 6,800-mile voyage between Murmansk and Vladivostok each summer. At best, the Arctic Sea route is difficult but the airplane helps greatly by telling the ship where to go to keep in open water. On the southern side, also, Siberia is closed from the Indian Ocean by the deserts, plateaus, and mountains of central Asia, by the great distance, and by jealousy.

Scandinavian Routes. The Scandinavian peninsula is like the rest of Europe in being served by a secondary route of steam railway giving quick connection with the other capitals of Europe. Express trains between Berlin and the Scandinavian capitals of Stockholm and Oslo are ferried across the Baltic. Commercially this peninsula is an island depending for its outside communication absolutely upon the sea, which envelops it so favorably for commerce.

[5] In 1938 Russian waterways performed 23 billion metric ton-miles of freight service, or one-sixteenth that of the railroads. In 1937 the port of Igarka at the mouth of the Yenesei shipped 90 million board feet of lumber, including 18 shiploads destined for Great Britain, Holland, and Germany.—See George B. Cressey, *Asia's Lands and Peoples*, McGraw-Hill Book Co., Inc., New York, 1944, pp. 304-305, 362.

The North Atlantic Route

1. Location Factors

The greatest of all ocean trade routes is that crossing the North Atlantic and connecting the two most commercial continents. This route links eastern America and western Europe, two very productive areas and the two greatest markets on earth. To a person who has not given attention to the geography of the North Atlantic, it might seem that this ocean possesses a multitude of trade routes. Yet there are certain geographical conditions producing a surprising similarity in the path followed by all of the ships going across this ocean from North America to northern Europe.[1]

Great Circle Sailing. An important factor leading to the use of this common path is what the mariners call "the great circle." This can be best understood by examining a globe, the only map that is accurate for large areas. By it one sees that in high latitudes the shortest line between any two points equidistant from the equator is not on the parallel running due east and west, but along the arc of the circle passing through both of the points in question, and dividing the earth into two equal parts—a great circle. The farther apart the two points in question are, and the farther from the equator they are, the greater is the poleward curve of the shortest line between them. Consequently, there are almost no straight east and west routes upon the charts to be followed by the mariner. He is forever following curves. With the exception of the airplane pilot, the navigator of a ship is the one man who is most directly concerned with the fact that the world is round.

It is rather astonishing to discover that the positively shortest air line from Sandy Hook to Liverpool passes directly overland through New England and Canada west of Nova Scotia. The more closely ships can approach this great circle line, the shorter is their voyage; consequently, as soon as it is safe to do so, all vessels leaving New York abandon their eastward course and swing northward along the line of a great circle, the exact point for this turn varying with the seasons. At all times of the year the vessel must proceed eastward, sometimes hundreds of miles, before it is permitted to turn to the north. Only by this means can the navigators avoid the worst dangers of the Newfoundland coast and the fog banks. The great circle swing makes the vessels from New York, Halifax, and Montreal approach each other before mid-ocean is reached and sail along within sight of each other. For a part of the year, often less than

[1] The ocean seems like a trackless waste, but if a considerable number of ships follow the same path for similar purposes during an appreciable period of time, we are justified in marking that path as a trade route. However, the thin lines on the map indicating the location of ocean routes do not have the same meaning. Each route has its own special character.—See Arthur J. Sargent, *Seaways of the Empire,* Adam and Charles Black, Ltd., London, 1930, and Alfred C. Hardy, *World Shipping,* Penguin Books, Ltd., London, 1943, pp. 21-100.

half, the St. Lawrence steamers make an exception to this by going north of Newfoundland.

The following facts, furnished by the Hydrographic Office of the Navy Department, Washington, in November, 1945, merit examination here:

Distances between Liverpool and New York:
- Track B (Southern)—Used April 11 to June 30, inclusive.
  - Westbound 3,172 nautical miles.
  - Eastbound 3,211 nautical miles.
- Track C (Northern)—Used from July 1 to April 10, inclusive, except when ice conditions necessitate the use of Track B.
  - Westbound 3,100 nautical miles.
  - Eastbound 3,132 nautical miles.

Distances between Liverpool and Montreal (via Cabot Strait):
- Track F—Used from May 16 to opening of Belle Isle Route.
  - Westbound 2,944 nautical miles.
  - Eastbound 2,954 nautical miles.
- Track G (Belle Isle Route)—Used from opening of the Strait of Belle Isle to November 1.
  - Westbound 2,755 nautical miles.
  - Eastbound 2,755 nautical miles.

Distances between Liverpool and Churchill (via 75 miles off Cape Farewell):
- Westbound 2,790 nautical miles.
- Eastbound 2,790 nautical miles.

An examination of the globe, or a photograph of part of it, shows that the east coast of the United States, of which we often think as extending from north to south, really lies so near east and west as to be practically a part of the great circle line from the Georgia coast to Scotland; so that the ship from our South Atlantic ports follows the coast and takes the same trunk route as those from the North Atlantic. This same principle goes even further and gives to the vessels from the Straits of Florida, that is to say, the vessels from the Gulf ports of the United States and Mexico, identically the same path across the North Atlantic.

In the process of a shipping controversy, the Liverpool Steam Ship Owners' Association once declared "that all vessels crossing the Atlantic to this country (Great Britain) from ports in North America take practically the same route from 60° west longitude." As a consequence of this fact, Norfolk is an important coaling station for the ships from Gulf and Caribbean ports. Even Nicaragua is within the territory of this same North Atlantic route, for it is but 323 miles further from Greytown to Liverpool via New York than via the shortest possible route. Ships sailing northward from the Caribbean can well afford to call at our eastern ports for way-cargo en route to Europe. It is thus plain that the North Atlantic route is a great trunk route with a string of branches for the different ports from St. Johns in Newfoundland to Havana, Veracruz, and Colón.

It is, therefore, exactly in accord with these basal facts of location that there has arisen a transshipment trade at New York and New Orleans by which the products of the West Indies and Caribbean countries are being forwarded to Europe by the great trans-Atlantic liners, and return cargoes come by the same route.

It is a working out of the narrowing longitude of high latitudes that causes Quebec and Montreal, which we are inclined to think of as being far in the interior, to be nearer to Liverpool than are New York and Boston; the same is

true of trading posts located far in the center of the American continent upon the western shores of Hudson Bay—a fact used by Canadian politicians as an argument for building the Hudson Bay Railway from the wheat fields of Saskatchewan to the port of Churchill, which is considerably nearer to Liverpool than is New York, as may be seen from the aforementioned figures.

Navigation Hazards. The North Atlantic route has the great advantage of being almost entirely devoid of reefs and shoals. Notable exceptions are Sable Island—the so-called graveyard of the Atlantic—east of the Maine coast and a few small rocks on the Grand Banks. These skirmish posts of the continent are so universally dreaded that the route for the trans-Atlantic steamers aims to interpose 60 miles of clear water between the ship and these destroying landspecks. This is the more necessary because of the mingling together of the Arctic current and the warm Gulf Stream which produces well-nigh continuous fog on the Grand Banks. The handicap resulting from these difficulties is well-illustrated in the St. Lawrence River, one of the feeders of the Atlantic route, where the narrow and rocky channel has been frequently the scene of great disasters and where at the present time ships must often tie up during the night. One result of these dangers is an insurance rate often several times as high as that for open sea voyages.

Another dangerous part of the route is Cape Hatteras, which really projects into the Atlantic and, with its long strings of sand bar reaching out to sea, must be rounded by hundreds of vessels from the south. In the temptation to save distance, many a good ship has ventured too near these bars and met a watery doom.

A serious menace to navigation is the danger of collision with icebergs, which break off the Greenland glacier and drift southward from the middle of March until late in July. Icebergs are especially dangerous south of the Tail of the Grand Banks, where there is greater congestion of shipping. Only one-ninth of an iceberg appears above the surface of the sea, and our Coast Guard patrol has reported some icebergs as long as 1,690 feet and rising 250 feet above the water. It was an iceberg that sank the crack White Star liner *Titanic* in April, 1912, with a loss of 1,517 lives. Since then shipping lanes have been shifted 2° 30′ farther south during the iceberg season, and our Coast Guard patrol boats send out warnings by radio reporting the location of large icebergs. Radar has now become a great aid in locating icebergs.

Winds and Fuel Supply. The North Atlantic, a region famous for its storms and strong winds, was, in the sailing vessel epoch, a route where some wind could always be had. The ship was never becalmed, and the record of the zone of calms shows this to be a matter of importance, although it was often necessary in the winter time to make a great detour to the south to avoid the steady North Atlantic winds from the west. This was particularly the case in the colonial times when ships were small and rigging was ill equipped for headwinds. In those days it was common for the ship to return from Europe by way of the Canaries and West Indies and beat northward along the Atlantic coast.

In the present epoch of steam no route

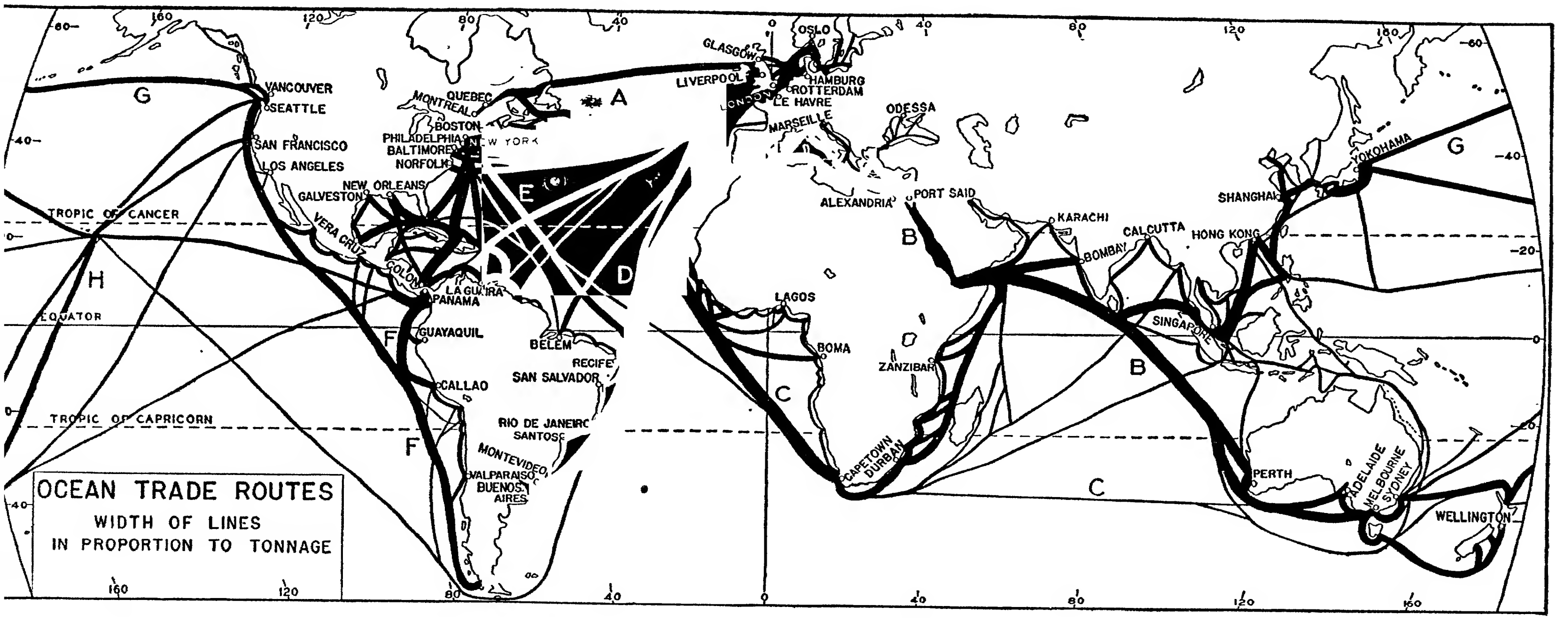
equals the North Atlantic in the abundance of the supply of fuel. Eastern America and northwestern Europe are producing three-fourths of the world's coal, and on both continents this supply is admirably distributed for the supply of steamers. On the American end there are four distinct fields: east Canada is supplied by Nova Scotia; the Middle Atlantic states, from Pennsylvania; Chesapeake ports, from Maryland, Virginia and West Virginia; at New Orleans and the other Gulf ports there is Pennsylvania coal, carried down the Mississippi River in barges at minimum cost; and Mobile has Alabama coal under equally favorable circumstances. The European end has a distribution of coal that is not less complete. Southern and western England with the ports of Bristol and Liverpool are supplied from the rich fields of Wales and Lancashire; Glasgow almost overlies the coal-fields of western Scotland. On the east lies Newcastle, synonym for coal; Antwerp and Rotterdam, the great ports of the Rhine, are in reach of Rhine-borne coal from Westphalia and Belgium; Hamburg and Bremen receive their coal very cheaply in tramp ships from Great Britain, and German coal can also come on barges from the Rhineland; and most Baltic ports now obtain their coal from Poland. Another fuel supply that should be mentioned is the oil of Texas, Kansas, and Oklahoma which is delivered cheaply by tankers and often by pipe lines to our Gulf and Atlantic ports. As fuel oil is more expensive in Europe, oil-burning liners leaving American ports usually carry enough bunker fuel for the round trip. Oil is the common fuel in liner shipping and is being used increasingly by modern tramps, and oil will continue to be a favored fuel as long as it remains plentiful and cheap.

2. *Traffic Characteristics*

Importance of the North Atlantic Route. For more than a century the North Atlantic has been the busiest of the world's ocean trade routes. At the outbreak of World War II, probably one-fourth of the world's merchant vessel tonnage was employed on the North Atlantic. No other route equals this route in volume and value of freight traffic, while the movement of passengers and mail across the Atlantic is larger than on all other routes combined. Upon this route new developments in ship construction almost invariably receive their ocean-going baptism. Here luxury, comfort, and speed are carried to a supreme degree. Here are to be found the world's largest and fastest passenger liners, the aristocracy of the shipping industry.[2] On no other route is competition among big shipping companies so keen.

It is upon this route that have occurred the fiercest fights for international supremacy. Here in the middle of the nineteenth century occurred the great Anglo-American duel between the rival American and British lines, the Collins and the Cunard. In this struggle the American line was the faster, but ultimately victory was not to the swifter. The present century has witnessed equally keen competition among the British, the German, the French, and

[2] In 1939 only 16 ships exceeded 30,000 gross tons in size, including the 85,000-ton *Queen Elizabeth,* the biggest thing that was ever budged by man. All of these super-liners are normally employed on the trans-Atlantic run, and all of them are subsidized.



is map merits frequent examination in connection with reading about the various parts of the world. What makes each particular line as it is? The major overseas trade routes ·trayed by the map are as follows: (A) North Atlantic, (B) Mediterranean-Asiatic-Australasian, (C) Cape of Good Hope, (D) European-eastern South American, (E) eastern rth American-eastern South American, (F) North American-western South American, (G) North Pacific, (H) North American-Australasian.

the American lines, which are here rendering the best ocean service for both freight and passengers that the world has ever seen.

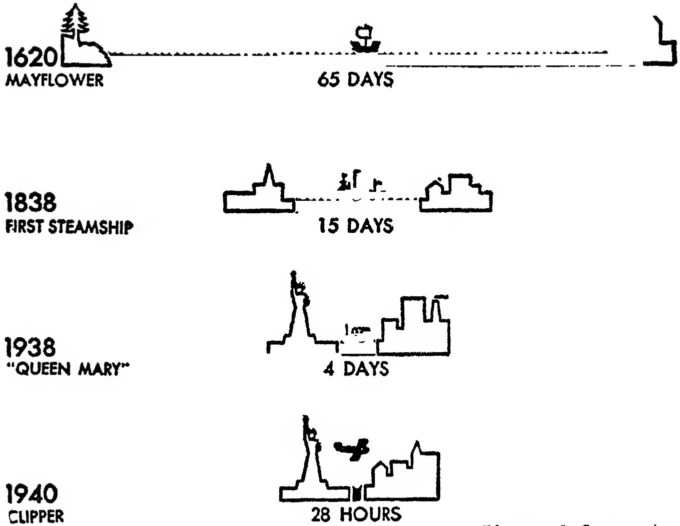
Passenger and Mail Traffic. From the first settlements at Jamestown and Plymouth until the enactment of a law in 1924 drastically restricting immigration, America was the mecca of European home seekers, and the North Atlantic was the world's greatest immigrant route. From 1880 to 1924 approximately half a million Europeans packed the steerages of trans-Atlantic vessels every year en route to new homes in the United States. In the first decade of the twentieth century, more immigrants landed on American shores than in all the years prior to 1850. While immigrant fares were low, the total income to passenger lines was large. Following the curtailment of immigration in 1924, some lines were forced into bankruptcy. To stimulate new business, the trans-Atlantic passenger lines were obliged to cater to the tourist trade by making comfortable accommodations available at reasonable rates. The poor and ambitious immigrant of former years is now replaced by the college student and others of ample means who spend a vacation in Europe. Today the passenger traffic is much more seasonal than it was 30 years ago, reaching a peak during the summer months.

Passenger liners carry mail, express, and small amounts of high-valued freight. Mail services on the North Atlantic have long been faster, more frequent, and more heavily subsidized than on any other route. The coming of regular trans-Atlantic airplane service presents a new problem for the passenger lines, for it is likely that mail, express, and much passenger traffic will desert the ocean liner for the much faster liner that flies through the air.[3]

Freight Traffic. Year after year the tonnage of eastbound freight on the North Atlantic is three or four times larger than westbound freight. Shipments from Europe to North America consist chiefly of manufactures and other commodities of high value and small bulk that move in parcel lots by liners. On this route British coal exports are insignificant, for the United States and Caribbean lands are well supplied with American coal. The westbound tramp occasionally is able to obtain a full cargo of Spanish pyrites, French chalk, German potash, Scandinavian pulp or newsprint, or British china clay, but usually the tramp that clears a European port for Canada or the United States must move in ballast. On the other hand, there is an enormous movement of foodstuffs and raw materials to Europe: grain, lumber, wood pulp, and dairy produce from Canada; iron ore from Newfoundland; petroleum, sugar, fruit, and hardwoods from the Caribbean; and petroleum, iron and steel scrap, phosphate, sulfur, cotton, grain, meat, apples, and other commodities, together with large shipments of manufactures, from the United States.

This lack of balance between eastbound and westbound traffic has definite effects upon the shipping industry. The liner is tied to its route and must leave on schedule. On westbound voyages most of its cargo space is empty. Hence, it is forced to charge higher

[3] For this very reason, the United States Maritime Commission decided in 1937 not to build any super-liners as large and costly as the *Queen Mary, Normandie*, and *Bremen*.



Pictograph Corporation

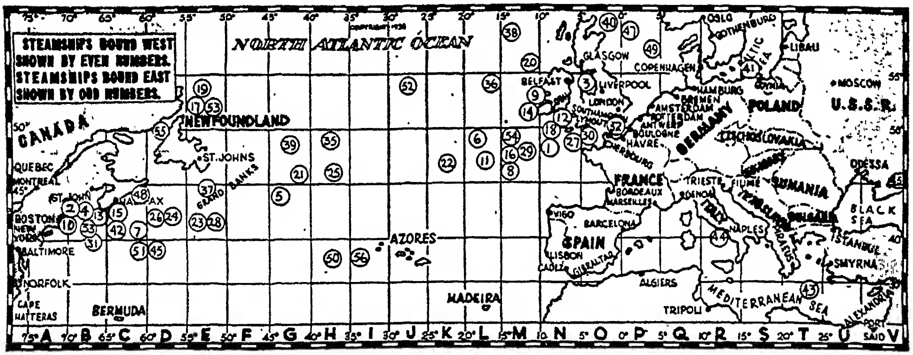
The ocean shrinks—for the hurry passenger, the hurry mail, and a very little air freight. It has not shrunk so much for the basal commodities upon which our economic life depends.

rates on eastbound cargo than if westbound cargo were available. On the other hand, the tramp may travel from Europe directly to North America in ballast, but it has an alternative—the triangular voyage. The tramp can always carry British coal to Argentina and Brazil. It may pick up a cargo of Argentine flax or Brazilian manganese or some other commodity, or it may move in ballast to Chile for a load of nitrate and carry it to the United States, where cargoes for Europe can be obtained.

On no other route has the tramp suffered so acutely from liner competition as on the North Atlantic. Between 1913 and 1937 the tramp's share of the grain trade declined from about 60% to 40% at Montreal, from 30% to 9% at New York, and from 61% to almost zero at Baltimore.[4] At our Gulf ports during the same period, the tramp's share of the cotton trade declined from about 95% to less than 10%; in the lumber trade, from 90% to nearly zero; phosphate, 80% to 13%; and sulfur, 80% to about 25%. These desertions from tramp to liner reflect the tremendous volume and growing regularity of cargo movement from the United States and Canada to Europe. The North Atlantic is not only the passenger-liner route par excellence. It is the best of all routes for cargo-liner service.

The traffic future promises that our freight movement will not increase so rapidly as it has in the past. America, with her increasing population and her great factories and mills, is using more and more of the raw material, has less and less for export to Europe. The fact that we are establishing manufacturing industries means also that we have a

[4] Halifax is an exception. When the St. Lawrence is frozen, about 10 to 15 million bushels of wheat are shipped to Europe via Halifax, and the tramp handles over 90% of this trade.



On July 9, 1939, a New York Sunday paper published this map, giving the location of 54 ocean liners en route across the North Atlantic. The northernmost were to Oslo, Gothenburg, Helsinki, and Gdynia. The southernmost were to Trieste and Piraeus. There were two from Rotterdam; London, six; Liverpool, five; Havre, three; Southampton, three. The Southampton boats may have come on from points further east.

lessening demand for European goods, so both upon the side of production and on the side of consumption there is a prospect of lessened dependence of America upon Europe, and relatively lessened demand for commerce upon the North Atlantic trunk route. The immigrant traffic is gone, but there is every indication of the steady growth of travel between the two continents both by sea and by air.

Competition Among Ports. One of the accompaniments of the nineteenth-century revolution in world commerce has been the changing of seaports. Seaports have changed in two ways. The first of these changes has been the physical renovation and rebuilding of the ports and deepening of harbors and channels to accommodate the enlarged steamship and the consequently enlarged trade. The second and yet more important change has been the shifting of the centers of distribution through the relative decline in the importance of the old, and the rise of the many new centers. These changes have been of greater influence in the North Atlantic than in any other of the world's great routes.

The great increase in trade since 1880 has produced a multiplication of the lines of vessels, and consequently a great breaking down in the centralization that arose in the distribution and collection of the traffic to and from a few great ports which had been monopolizing it. There was a time when London and Liverpool almost monopolized the line traffic between Europe and America, but other cities rose to the position of claiming their share from America direct rather than through the intermediate ports. Liverpool saw Bristol rise to the south of her, Glasgow to the north of her, Manchester behind her, and Belfast across the Irish Sea. London has seen the rise of Antwerp, Hamburg, and Le Havre, which ports in turn have established coasting lines and have snatched from London a part of the distributing trade of Scandinavia and Russia. But this was not the end. The establishing of coasting lines was scarcely complete at Hamburg and Antwerp, when the same process went further,

and yet another set of rivals arose. There sprang up a direct trans-Atlantic connection that gave to Hull, Copenhagen, Stockholm, Leningrad, and Bordeaux the ability to get some of their goods without dependence upon either the new intermediaries, Hamburg or Antwerp, or the old intermediaries at London or Liverpool.

A similar development has occurred on the western end, where New York, while growing steadily in the annual amount of her traffic, is proportionally losing trade to her rival ports like Montreal, Boston, Baltimore, Norfolk, New Orleans, and Houston. At present nearly all of Canada's commerce with Europe passes through the port of Montreal when the St. Lawrence is open, and through Halifax, St. John, N. B., Portland, Me., Boston, and New York in the winter months when the St. Lawrence is frozen.

But with all the multiplying of lines and of services there is no multiplying of routes, only another straw is added to the mighty sheaf of tracks bound together in the mid-Atlantic but spreading at the ends to include Finland and Spain, Newfoundland and Panama.

The rising of new services from new ports has apparently had little influence on the growth of trade in the old. The ports of Europe are steadily increasing in traffic and are chronically and almost universally outgrowing themselves and making new facilities. In Antwerp, Belgium, the harbor authorities have gone into the fields beyond the city and laid out a great new harbor, and Antwerp is now the greatest freight port on the continent of Europe.

Manchester, tiring of what were considered high freights to and from Liverpool, built a ship canal 35 miles long and a harbor. It gave the desired low rates by direct ship and then by the railroads that competed with the ships. The year the canal was opened (1894) its traffic was 686,000 tons, and in 1938 it handled 6,410,000 tons of freight. Manchester now imports about half as much wheat and raw cotton as Liverpool, but it surpasses its rival in the import of petroleum and wood pulp.

By dint of sheer expenditure London has passed Liverpool and become the premier port of Great Britain. London is not a seaport city—she is 55 miles up the little Thames River—but the river has been deepened and developed until large ocean vessels now come within a few miles of the British metropolis. London docks have grown until they now cover more than four square miles. London and Liverpool together handle about 60% of the total foreign trade of Great Britain, the former leading in imports, and the latter in exports.

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The Trade and Trade Routes of Asia

Geographic Handicap to Asiatic Transportation. Asia is old. Asia is in an infancy in which the old peoples, gripping the tools and mechanisms devised in the West, are starting forward to the rebuilding of their old continent, and to the rediscovery of world power. She is the seat of ancient civilizations and of the oldest extended commerce; yet that commerce has always been handicapped by geographical hindrances which will tend to impede her new trade as well. The continent of Asia is five times as large as the United States. Its mere size divides its different parts by enormous distances. The conformation of the land has presented other barriers more prohibitive than distance. There are no large inland seas reaching deep into the land mass, as in Europe. There are no rivers flowing from the great central region, and trade must depend upon land transportation. Deserts and mountains add difficulties that have been well-nigh insurmountable and have limited the commerce of this section to small proportions. The heavy commerce of Asia, like her dense population, has been dependent upon the great rivers and river plains of the south and east; and here only has there been trade in the food supplies and the heavier articles that are typical of present-day commerce. Extensive rail nets have been developed in Japan and India, where the bulk of all inland commerce now moves by rail, and in Siberia the Russians have made remarkable progress in building railroads. The rest of Asia may yet be said to lie undeveloped, awaiting modern means of transportation.

The Importance of Asiatic Rivers. The Yangtze is the greatest of the river thoroughfares by which the commerce of Asia has been supported. Running from west to east through the heart of China, it has 750 miles of waterway for ocean steamers and much more for native boats. The Yangtze is the great commercial artery of China for three reasons. First, it has navigable branches flowing into it from north and south, and a far-reaching system of canals that open up great tracts of territory. Second, there are tremendous populations dependent upon these waterways. Third, there is virtually no railway competition, as railroads parallel only a small part of the lower course of the Yangtze. The rapids of the Yangtze gorges are still a great hindrance to traffic upstream, but the river gives the western province of Szechwan, with its many millions of people, a better outlet than the state of Ohio had in 1810, when all agricultural produce had to be sent to New Orleans by flatboats which could not return. The Chinese are able, by arduous human labor, to tow their boatloads of freight up the rapids. It is plain why Shanghai, the gateway to this great valley, is one of the great ports of Asia and of the world, and is destined to greater growth. It is the New York of

China, handling two-fifths of its foreign trade.

In south China the Si or West River and its canals perform the same function as the Yangtze, but for a smaller area, having as outlets the great ports of Canton and Hongkong. In north China the great Hwang River is useful for navigation only for short stretches because of the vast quantities of loess mud it carries. The metropolis of its wide valley basin is Tientsin on the Pei River, which acts as the port for Peiping, with which it was connected by one of the first railroads in China. The only other rivers of importance are the Amur-Sungari in northern Manchuria, navigable by steamers as far as Harbin, and the Liao of southern Manchuria which is useful to shipping from Newchwang to some distance north of Mukden.

In Indo-China, Siam and Burma the settlements of trading people are all on or near the navigable rivers Mekong, Menam, Salween, and Irrawaddy, which are served by both native craft and steamers. Thus Rangoon, at the mouth of the Irrawaddy, Bangkok near the mouth of the Menam, and Saigon on the delta of the Mekong became the great rice-exporting ports of the world. They also export much teak timber that has been floated downstream.

In India the seats of ancient empire and trade were the rich valleys along the navigable courses of the Ganges and Brahmaputra, and in lesser degree along the Indus. Here are the historic names. The British Administration in India has improved some of these rivers, but the railroads have taken most of their trade. Thus, in the middle Ganges Valley even heavy and bulky commodities move by rail, and steamer service on the sand-choked Indus has been abandoned. However, trade continues to flow down through the valleys to the great port of Calcutta on the delta of the Ganges and to Karachi near the mouth of the Indus. Bombay, at the foot of the major gap through the Western Ghats, is primarily a railroad city, but it is also the greatest port on the west coast of India.

Caravan Routes. With the slight exception of the navigation of the Tigris, the commerce of the remaining and by far the larger part of Asia, was, until the recent railroad building in Asiatic Russia, dependent upon the land caravan. The entire north is handicapped by the Arctic ice; and in the other three directions cyclopean difficulties present themselves to the caravan drivers. On the south a vast wall of mountain and plateau under various names reaches from Asia Minor to Tibet and on to the cliffs that look down on the China Sea. On the west are the wide and often arid steppes leading into the remote east of Europe. In the center the deserts of Turkestan and Mongolia, beset with mountain ranges, connect uncrossable Tibet with the Arctic wastes of east Siberia. For thousands of years the caravan has contended against these obstacles, using horses, mules, donkeys, oxen, yaks, and men as pack animals in the mountains, camels in the desert, and carts and sledges on the flat plains. These traders have traversed astonishing distances. The men of Peiping and Turkestan have for centuries been familiar figures at the Russian fairs of Gorki (Nizhni-Novgorod).

The caravans from China to the west and northwest have been chiefly the caravans of the desert, following the

By Deane Dickason, from Ewing Galloway

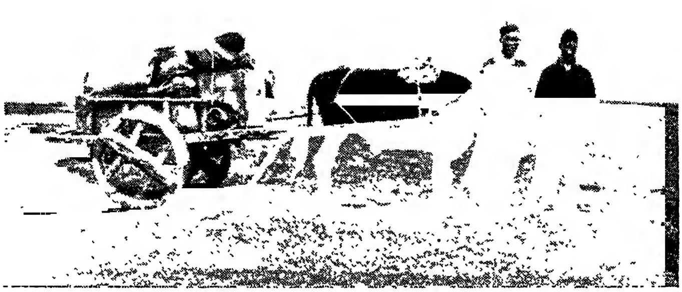
A train of two-humped camels, sometimes called the Mongolian camel, in the streets of Peiping, loaded with wool and other merchandise from interior Asia. The camel train is a familiar sight in the dry heart of the eastern hemisphere from Casablanca on the Atlantic to the Red Sea, to the Persian Gulf, to the Pamir, and on across the wastes of Turkestan and Mongolia, to Peiping, almost to the shores of the Pacific Ocean. East of Mesopotamia, it is chiefly the two-humped species; in Arabia and Africa, the one-humped camel, often called dromedary.

routes of the desert, which comes down to within less than a hundred miles of Peiping, reaches northward nearly to Lake Baikal, southwestward to Tibet and westward to the Caspian Sea. This region is much like the arid region of the United States, having oases and irrigation settlements here and there, where some snow-fed stream reaches the plain, but the desert stretches of Asia are much greater in area and often more complete in aridity than those of the United States. Across this waste China has for ages had a caravan trade, and the camel has been a familiar sight in the streets of Peiping since before the birth of any European nation.[1] The most important branch of this overland trade was that with and through Siberia, the routes from Peiping and Hankow combining and reaching Lake Baikal by way of the desert station of Urga.

The Chinese caravan route next in importance passes up the Hwang Valley, across Chinese Turkestan into Russian Turkestan. At Hami in longitude 94° east the route branches, the southern arm crossing the high ranges via Kashgar and the northern going to Tashkent via Kuldscha.

A third route of lesser importance connects Chengtu, the capital of the rich province Szechwan on the upper Yangtze, with Lhasa and Tibet, while a fourth connects Yunnan, a mining city in southwest China, with Bhamo in upper Burma. The Burma Road, of which so much was heard during a part

[1] The base for this camel trade is constantly changing. As railways are built westward in China, old caravan routes are surrendered, and the camel train makes its start from the new end of the line.



Carts like this come across the Mongolian desert in strings half a mile long. Especially do they bear wool and skins from the dry ranges to the western and landward ends of the Chinese railways. Not recommended for joy riding.

of World War II, connected southwest China with the lands that drained to the Bay of Bengal. This was perhaps the last great burst of the caravan trade.

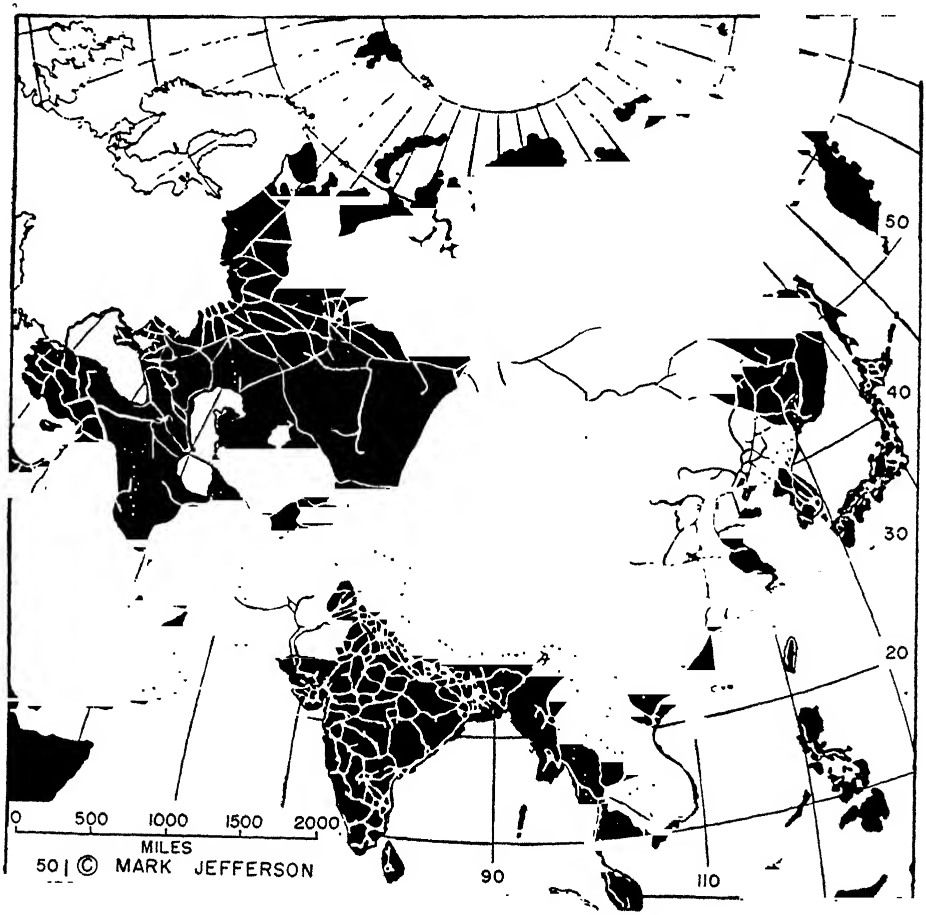
The routes that center in Turkestan were, before the coming of the Russian railroads, continued to Europe by a direct route from Tashkent to Orenburg at the end of the Urals, and by a more southern route via the Caspian and Black Seas to Istanbul (Constantinople) and south Russia.

Commerce that must traverse these enormous distances on pack animals over mountain, desert, swamp, dune, and grassy plain has pressing limitations of high freight rates which exclude anything but goods of the highest value—luxury goods, metal work, silks, cloth, skins, leather, rugs, tea, and spices. The most important of these routes, the one that passed through Siberia, had tea as the chief article of its commerce. The overland tea cargoes traveled by a variety of means. At Lake Baikal that route reached a well-watered country, and the camel returned to his desert. The mud of Siberian springtime stuck fast the wagon wheels of commerce, which in that region was therefore carried on almost exclusively by means of sledges over the dependable snows of the Siberian winter. Therefore, the tea rested where the spring thaw caught it and proceeded westward when the next snowfall again permitted the movement of goods. Such were and to this day yet remain the only means of commerce and travel in vast areas of central Asia where the railroad is still far from the home of the settler. Naturally the consumption of the goods from the outside world is light where such conditions prevail, and the inland settlements have always been essentially self-sufficient.

The day of the transcontinental caravan is almost over. At best it is a poor, weak rival of the poorest railway; and, wherever they compete, the caravan station becomes the embodiment of hard times and decay. The first great falling off in the overland trade came in the last century with the establishment of steamship service connecting the newly opened ports of China with Odessa, and the new railways reaching thence into

the interior of Russia. The region west of the Ural Mountains could be supplied with Chinese tea and silk more cheaply by the Yangtze junks and the new water route than by the old routes, which had then no territory left but the domains of Asia. This territory was soon invaded by further improvements, and the Trans-Siberian and the Trans-Caspian railways have become the trunk lines for the trade of interior Asia and the caravan is reduced to being their distributor and feeder.

The Trans-Siberian Railroad. The vast expanse of Asiatic Russia is served almost entirely by one great trunkline



Asia is big, bigger than both Americas, nearly four times as big as Europe. It is big and inaccessible. Its dry heart is walled in by mountains from the Bosporus clear around to the Amur River Basin, with only one break at the Zungarian Gap in West China. Its cold north is made inaccessible by the great northern forest, the peat bogs and marshes of the Tundra and the floating ice, which almost covers the Arctic Ocean. This sea was essentially uncrossed by commerce until we could fly high and find the openings for the boats, which now work their way through each summer with airplane guidance. The absence of railways serves to emphasize the essential inaccessibility of most of the area at the present time. As to the completeness of the railways of Asia—the senior author recalls the indignant complaint of the Germans as they invaded Russia that, "Here are railroads that are not on any map."

railroad and its branches, the Trans-Siberian Railroad, which was begun in 1891 and completed in 1904. Prior to the coming of the railroad, Siberia was little more than the home of fur traders, nomadic herdsmen, and hapless political exiles. For two decades prior to World War I, thousands of Russian settlers streamed into the fertile black-earth belt that tapers eastward toward Lake Baikal, this movement reaching its peak in 1908 when 758,000 people went to Siberia to live. To the newly developed country the railroad brought settlers and manufactures, westbound traffic consisting of Siberian wheat, butter and cheese, meat, hides, tallow, wool, and furs, and also Chinese tea and silk. Under the Soviet regime, largely since 1930, came a great economic survey and a second and greater migration of men to Siberia. Mineral resources were vigorously developed, and industrial centers arose east and south of the Urals, at Novosibirsk and in the Kuznetsk Coal Basin, at Irkutsk near Lake Baikal, and at Khabarovsk and Komsomolsk in the Amur River Basin.

A better balance between agriculture and manufacturing resulted from this development, and middle and eastern Siberia have become more self-sufficient, thereby reducing the need of long-haul traffic to and from European Russia. To serve the new urban-industrial areas, branch lines have been built southward from the Trans-Siberian Railroad. The greatest development is the railway grid serving Sverdlovsk, Chelyabinsk, Magnitogorsk, and other cities in the Ural area, this section having easiest access to large markets in European Russia.

A notable achievement of the Soviet regime has been the construction of the Turk-Sib (Turkestan-Siberian) Railroad, which extends from Novosibirsk around the tip of Lake Balkash southwest to Tashkent. Here it connects with one older line that goes west to the Caspian with its boats and their Volga connections and with another rail line that runs northwest via Orenburg directly to Moscow. Siberian grain and lumber move southward into dry Turkestan, where cotton is grown under irrigation and is now shipped to textile mills in both European and Asiatic Russia.

Siberia is a land of opportunity for modern Russia very much as the Great Plains, Rocky Mountain states, and the Pacific coast at one time were the frontiers of settlement in the United States. The great need of Asiatic Russia today is more railroads and more men, but even after the railroads have been built, the handicap of distance will remain. To make the 5,500-mile trip from Leningrad to Vladivostok by Trans-Siberian Express requires 9½ days, or as much time as the fastest trip by water and rail from London to San Francisco.

At the present time the heaviest freight and passenger traffic on the Trans-Siberian Railroad is in the West, the most densely populated part of Siberia which lies adjacent to European Russia. Intermediate traffic is steadily increasing, but through traffic between the cities of European Russia and Vladivostok is small. In the summer of 1945 this long double-tracked life-line of Siberia carried hundreds of thousands of Russian troops, together with vast quantities of supplies, from the European theater of war eastward to the Manchurian frontier, enabling Russia to

strike a blow at Japan just prior to the conclusion of World War II.

In normal times it is likely that ocean-to-ocean traffic between Leningrad and Vladivostok will consist chiefly of passengers, mail, express, and small amounts of high-valued freight. It is likely that heavy and bulky commodities will continue to move by the longer but much cheaper sea routes rather than by rail. Prior to World War II, regular ocean freight service was maintained between Odessa and Vladivostok, the distance being 13,264 miles via Suez and 14,177 miles via Panama. However, it is difficult to predict what the Russians can and will do. In a land where government ownership prevails, if some high commissar gives the word, freight will move by rail.[2] Such words as "cost" and "profit" are virtually unknown in the modern Russian vocabulary. In the fast-moving Russia of today, the difficult task seems to be done almost immediately, while the "impossible" merely takes time. The normal economic procedure would appear to be the service of central areas by water-borne traffic from the Baltic Sea, the Black Sea, Vladivostok and Port Arthur (southern Manchuria).

The Trans-Caspian Railways. East of the Black Sea only 5 railroads cross the long frontier of southern Russia and central Asia, namely, into Turkey, Iran (Persia), Mongolia, and two lines into Manchuria. In each of these areas, with the possible exception of Turkey, Russian influence is strong. The railroad is not only a carrier of men and goods, but it is a purveyor of language, customs, and ideas. Thus, at Alma Ata the new Turk-Sib Railroad comes within 200 miles of the western Chinese province of Sinkiang, which has more intimate relations with the Soviet Union than with the rest of China in spite of the fact that a 5,200-mile motor highway now crosses Sinkiang and links Alma Ata with Chungking. The coming of the railroad opens new markets and sometimes completely changes the economic life of a region. Such was the case of the Trans-Caspian lines, which were built in the central Asian provinces prior to World War I. There one-half of a Trans-Asian railway has been made by the extension of the European transportation system to the backbone of Asia—to the mountain wall separating Russian and Chinese Turkestan.

The first link in this chain of railways at the south was the line connecting Batum on the Black Sea with Baku on the Caspian Sea. Steamers from this point and also the Volga connect with Krasnovodsk on the eastern shore of the Caspian whence the line passes Merv, Bokhara, Samarkand, and reaches Andijan in farthest Fergana, with branches to Tashkent on the north; on the south, to Kushk on the Afghan border. A more direct connection with Russia is the line from Orenburg, at the end of the Urals, to Tashkent, the northern terminus of the first line. This is one of the old caravan routes that gave an outlet to central Asia before the Trans-Caspian railway caused it to be almost deserted.

Trans-Caspia, Bokhara, Turkestan, Fergana and Kiwa, the territories served

[2] When the great steel center at Magnitogorsk was first being developed, all coal and coke had to be carried 1,400 miles by rail from the Kuznetsk Basin, the longest coal haul by rail in the world.

by these new lines, compose an 800-mile stretch of arid and, in part, desert country, irrigated in places by the streams that flow from the high and snow-clad mountains to the east and south. The habitable sections are comparatively small, but fertile. The climate is good, the agricultural products rich and varied. Cotton, cattle, sheep, grains, forage crops, fruits and vegetables of the temperate zone have enabled these oases to support a population as dense as that of agricultural western Europe, and with the coming of the railway, the sluggish caravan trade was quickly succeeded by a lively commerce. The ability to reach the European markets led to a great increase in the production of cotton,[3] and the dried apricot, which had been produced for local use from time immemorial, suddenly found a great market in Russia, making much traffic for the new railroad.

Tashkent, after a sleepy oasis existence of many centuries, has in a few railroad decades grown almost as Chicago grew. The population was reported to be 155,000 in 1897 and 585,000 in 1939. Recent claim is a million.

Possible New Railways Across Asia. A direct rail route from Europe to India by way of the low passes of Afghanistan is one of the future possibilities. The branch line of the Trans-Caspian from Merv to Kushk on the Afghan boundary is not far from Herat, and separated from it by the easiest pass in the entire mountain system between Armenia and Mongolia. On the southern side the railway system of British India has been pushed upward past Quetta to Chaman on the Afghan boundary near Kandahar. There are no serious engineering difficulties in the way of connecting the two railroad systems, and commerce would be much increased by another radial outlet to the vast landlocked mass of central Asia. Political jealousy is the only reason that the connection between these two national roads now so near together for several decades has not been made. Both roads to this frontier are military roads, and were not built for economic reasons. Therefore, the caravan still connects India with Russia, and no one can predict how long international jealousy will block the railroad demanded by jostling trade.

The Khyber Pass is 20 miles of easily traversed valley through which the Macedonian armies passed, as have countless bands of emigrants. Unfortunately, this easily traversed gateway into a continent is little more than a fort. A double track railroad with no traffic runs its length and connects with nothing on the end toward Russia. There, the day this writer saw it, a stone guardhouse and an armed sentry guarded the Afghan boundary—with an armed Afghan on the other side. "What would you do if I stepped across the boundary?" said a traveler from Indiana. "I would shoot you," said the Afghan. The gentleman from Indiana believed the Afghan, turned upon his heel, and started back to Indiana. The mountains on both sides of the valley pass are pep-

[3] Within two decades after the railway was built, cotton became one of the most important money crops from the irrigated fields of the oases. Whereas production was formerly limited to Soviet Middle Asia and a small area in the Transcaucasus, cotton is now grown near Astrakhan on the lower Volga, along the Kuban River, and in the southern Ukraine as far north as 48° N. Lat. In 1937-39 the Russian cotton output amounted to about 4,000,000 bales a year or four times the 1909-13 average, and imports were less than 90,000 bales a year. Central Asia is a great aid to Russian self-sufficiency.

pered with blockhouses high up on the cliffs where riflemen may protect the road through the Pass which should be one of the great commercial arteries.

Yunnanfu, the capital of Yunnan, the rich mining province of southwestern China, was reached in 1910 by a 450-mile French railway from Haiphong on the Gulf of Tonkin.

Two other rail lines reach northward toward the Plateau of Yunnan. One is a tentacle of the Indian railway system that extends through Assam as far as Sadiya near the border, where India, China, and Burma meet. It is only 400 miles from the navigable waters of the upper Yangtze but the terrain, ferocious mountain ranges, does not invite the railroad builder. The other line runs northward from Rangoon through Mandalay to Myitkyina in the upper Irrawaddy Valley, and from Mandalay there is a branch line extending northeast to Lashio, terminus of the famous Burma Road. As yet, Burma and India are not connected by rail nor is there great need that they should be so connected. It is jungle and mountain versus the open sea.

Central Asia affords the possibility for another great railroad—to traverse the Hwang Valley and penetrate the deserts to Hami and Kashgar in eastern or Chinese Turkestan. This road, which is now completed as far as Sian (or Singan), the capital of the province of Shensi, would be the eastern counterpart to the Trans-Caspian lines of Russia; the resources along the route are promising, but the connection with the Russian systems would be improbable, as there are few commercial reasons to make it profitable to surmount a mountain range whose lowest passes are higher than the highest peaks of the Alps. This route from Peiping to Kashgar, followed by camels for thousands of years, passes the coal-fields of the provinces of Shensi and Kansu, and the entire route is a promising though largely unprospected mineral region. In the upper Hwang province of Kansu is the westernmost extension of Chinese agriculture and an important wool-producing region. The habitable part of eastern or Chinese Turkestan is a succession of small oases along the foot of the central mountain range, and, like the oases of western Turkestan, depends upon the melting snows for life.

If you think of this land-locked area as another Utah and another Nevada, with double the population of these states, you will more nearly appreciate what is there, namely, half a million square miles and a million and a quarter of people (some say more than that), with access to oases, pastures, mountains and minerals. If capital could have been as secure in this region in the last forty years as it is in Utah, there would doubtless have been a splendid railroad connecting Sinkiang (eastern Turkestan) with the sea at some place, probably China. The shorter route to the Arabian Sea would have to cross heavy mountains and political jealousies.

The Bagdad Railway—the Through Route of Western Asia. An Asiatic project of present importance for international trade is the railway connection between the Mediterranean and the Persian Gulf through a region of wool, dates, and minerals. This was one of the most important international routes in the days of the medieval caravan trade between Europe and the Orient,

before the discovery of the sea route to India. Revived as a railway project, the Bagdad Railway, through the enthusiasm of Germany and the subsidies of Turkey, was built nearly the whole length of Asia Minor before World War I. Eventually various missing links were filled in, and the railroad now extends from the Tigris River port of Basra northward through Bagdad and the Mosul oil fields to the junction point of Mardin, which is connected on the west with Mediterranean ports and on the north with the Bosporus port of Uskudar (opposite Istanbul). Hence, the fertile flood plain of the Tigris and Euphrates, once the seat of mighty empires, is now linked by rail with the Mediterranean world. This plain has lain waste for several centuries since the Turkish conquests.[4] In 1913 a British-built dam and a reconstructed irrigation canal were opened to service, through a concession granted by the Young Turk Government which was then in control at Istanbul. The valley is as good as it ever was and will make a home for millions. Some of the canals of the ancients only need repair. Added interest is being taken in Iraq because of the productive oil fields near Mosul. The British, who have controlled Iraq since World War I, are anxious for a source of cotton under their own control and are looking to these hot valleys for a future cotton supply. All of which will add to the importance of the new railway.

Iran (Persia) possesses a little of the Mesopotamian lowland, rich, oily, irrigable, accessible to ships. This small section accounts for the leading exports of Persia, petroleum, cotton, and dates from the bank of the great river, shipped by steamer from Basra and the Persian Gulf.

Basra is the outlet for only a small corner of Iran. Most of the country consists of high arid plateaus; the population lives in densely peopled irrigation settlements surrounded by vast arid pasturelands, over which nomads follow their flocks. Skins are a natural export. This is also a natural setting for the rug industry in both tent and town.[5] The pride of the nation is the railroad crossing the country from Bandar Shaw on the Caspian Sea through Teheran southward to Bandar Shapur at the head of the Persian Gulf, a line that was of vital importance for the transshipment of supplies to Russia during World War II. The northwestern part of the country is reached from Batum by the Trans-Caucasian railway, from which a branch has been built as far as Tabriz. In the southeast a line from Quetta and the Indian railway net crosses northern Baluchisatan and comes a little way over the Iranian border. To this day, most of the plateau of Iran and all of

[4] The large and prosperous community, depending upon one irrigation canal for its very life, was a particularly easy victim for the Turk in the exercise of his genius for misrule. The farmer depending upon rainfall had at certain times certain crops that could be taken, but it is reasonably easy to keep enough to save life. The herdsman may get out of sight with his flocks, as the age-long strife of Bedouin and Turk attests, but the band of Turks at the head of the irrigation canal held over the heads of the irrigationists the power of life, death, and all exactions. Hence the centuries of desolation and unused possibilities of Mesopotamia.

[5] The Oriental rug is a nice adjustment to geographical conditions. It is highly valuable and can stand the high cost of long caravan journeys from inland points in west Asia. The wool is furnished by the flocks living on the scanty pasturage of the semiarid lands. The weavers live in densely peopled oases where they divide their time between household manufacture and tilling their irrigated lands.

Afghanistan are still served by the caravan or the wagon road with the truck and the flivver performing miracles of transport in what most of us would call impossible places.

Most of Arabia is desert, so absolute that it cannot be crossed between Damascus and the Indian Ocean. So far as known but two white men have made the land journey from the Red Sea to the Persian Gulf since Roman times. Arabia is practically devoid of both trade and trade routes in the modern sense. The pious desire of the Mohammedans to visit Mecca has made it for centuries the objective of a vast travel and has resulted in the only railway of Arabia—Damascus to Medina. Most of it has been out of commission ever since Lawrence blew it up in World War I. There is now talk of restoring this railway. Extension to Mecca is the final goal.

The Importance of Southeastern Asia. The emphasis that has been placed in this discussion upon the long and plodding caravan routes or the imposing railway projects of new or planned lines in Siberia, central Asia, Asia Minor, Mesopotamia and Iran should not be permitted to cause anyone to overlook the fact that the potential center of gravity of Asia lies in China, Japan, and India and the countries of Indo-China lying between them. Large areas in Siberia and most of Asia west of the Indus are empty lands, with scarcely 50 millions of people. Most of this part of Asia is too dry or too cold for great communities, the exceptions being a strip across central Siberia and occasional small and scattered areas elsewhere. It is a land in the main much like our semiarid West, where nearly half the area of the United States has less people than some eastern states. Southeast Asia is soaked in summer by the monsoon rains, and there are the crops and the people. In India and southeast of a line running from Calcutta to Harbin in Manchuria live half the people of the entire world. Theirs are the trade routes of a commerce that is to be stupendous as the age of machinery develops. Newchwang, Tientsin, Shanghai, Canton, Hongkong, Singapore, Calcutta, and Bombay are the termini of great and growing routes. Fortunately, most of the people tributary to these ports live comparatively near the sea, and their transportation problem is physically simple.

India, Siam, and the Malay Peninsula. India is now threaded with 41,000 miles of railway lines, and her extensive rail net stands in sharp contrast with the paucity of railway development throughout most of the Asiatic mainland (see Fig. 840). The ports of India are growing in population and commerce. Calcutta is the world's greatest jute exporter, ships a large proportion of the Indian tea crop, and is the port of entry for the greater share of the imports. Karachi is a grain port. In Madras and Bombay we have cities that depend chiefly upon the railroads that center there. In this respect Bombay is a nineteenth-century city, a railroad city, and its location near the districts of wheat, cotton, and oil seed production has made it, like Calcutta, one of the leading ports of Asia. Commercially it is a city of the West, dependent upon the railways built by the British, but in the large shipments of essential oils it shows its dependence upon the cheap labor of a densely peopled land.

Much produce is floated down the rivers of southeastern Asia. We have seen boys serenely sitting on rafts of coconuts such as this and placidly floating down the Philippine rivers. To make the raft, a bit of fiber is cut at one end of the outer husk of the coconut and pulled out far enough to tie to a corresponding piece of fiber from another coconut. Thus a circular chain of coconuts is made and others are thrown into the middle of it until they pile up as here shown, and finally the whole thing floats away downstream.

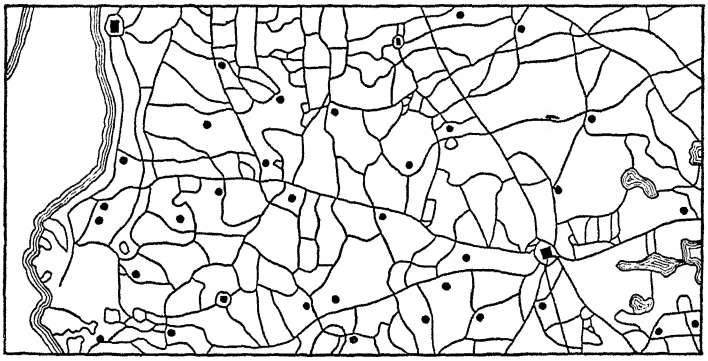
In the background, coconuts, bamboos, bananas—a fine display of the humid tropic forest growth, displaying their common characteristic—multiplicity of varieties—good for the botanist, bad for lumber.

Burma and Siam, long dependent on their rivers, now have a few railways, the principal line of Burma running from Rangoon to Mandalay and on up the valley of the Irrawaddy to Myitkyina not far from the borders of Tibet. The Northern Line of Siam runs from Bangkok to Chiengmai near the Burmese frontier. In 1909 Britain increased her sphere of influence in upper Siam by 17,000 square miles at one sweep, and in consideration thereof arranged for a loan whereby Siam could finance (and the British build) a railway from Bangkok down the Malay Peninsula to Penang, and thence to Singapore on the Strait of Malacca. Singapore is now the great world port for the shipment of crude rubber grown on the plantations of the Far East and has in addition large exports of tin, copra, coconut oil, palm oil, canned pineapples, iron ore, and spices.

Most of China Still in the Man-power Stage. The commerce and transportation methods of China have been well described by a careful observer.[6]

"If we look back to the seventeenth century we find our ancestors making use of methods of transportation, manufacture and agriculture which differ only in a minor way from those now used in China. . . . The horde of junks, large and small, which ply the waters of the canals upon the eastern plains, carry millions of tons, both of native and foreign goods, each year. . . . Along the river banks at nearly all of the large cities of eastern China there is a mass of junks and smaller boats so densely

[6] Eliot Blackwelder, "Transportation in Interior China," *Jl. of Geog.*, vol. 10, November, 1911. The passage of time since Blackwelder's journey has brought little change to most of interior China.



China has few railroads, but look at this map. It is about one and a half times the size of an ordinary American county, therefore it has a good highway net over which the farmer can scull his boat and take his produce many miles at a minimum of expense. The maintenance of the canal costs nothing, because the farmers are glad to scoop out the mud to fertilize their fields. (From F. H. King, *Farmers of Forty Centuries.*)

packed that the traveler is moved to wonder how each owner ever finds his own boat. The bare masts make a veritable forest around such great cities as Hankow and Canton. As is well known, these junks are used as permanent habitations by thousands of families who spend most or all of their lives in these movable homes. The internal traffic carried on by means of the junks is enormous in volume but has never been reduced to figures. When the wind blows in the right direction, the skipper of the junk hoists the familiar sail strengthened with bamboo slats. But at other times—and these probably seem to the poor coolie all too numerous—the boat must be dragged or 'tracked' by the crew wearily tugging at the long hawser made of thin twisted strips of bamboo. . . .

"On land two vehicles are most in use for both freight and passenger traffic—the cart and the wheelbarrow. The carts are small cumbersome affairs, very heavy in proportion to the loads they carry. This heavy construction has probably been adopted because the roads are so bad that a lighter cart would be shaken to pieces. In western countries local or general governments build and maintain the principal roads, but in China this is not the practice. . . . Among the mountains, pack-animals and men afford almost the only means of transportation. Carts are available locally in the broader valleys, but they cannot cross the rugged passes from one valley to another. . . . The idea of doing anything for the common good seems utterly foreign to Chinese thinking. Thus it happens that instead of improving roads so that large vehicles may be used and drawn at a fair speed, both the vehicles and the speed are adjusted to the inexorable demands of roads, which are usually as bad as they could possibly be.

"The great popularity of the wheelbarrow in China is probably due to the fact that a vehicle with one wheel can more easily take advantage of the best parts of the road than one with two; furthermore, it requires no draft ani-

mals. The freight-barrow used by the Chinese has a capacity of 600 to 800 pounds, and, like the cart, is a very stout, heavy machine. It is made of wood throughout. There is no more characteristic noise in China than the incessant squeak which arises from the ungreased axles of the wheelbarrows in town and country. The barrow is not always a one-man vehicle; often a donkey or a mule is hitched to the front of it, after the manner of a plow; and when the wind is favorable the thrifty coolie not infrequently rigs a sail to aid him in his weary struggle with a load which always seems much too big for him. . . .

"There are coal mines in Shantung [one of the eastern provinces] whose entire output goes by wheelbarrow to cities and towns 50 to 100 miles away. In the case of coal, the rapid increase of the freight charges limits the sale to a small district. More valuable commodities are often carried much farther . . . low grade commodities such as coal, building stone and grain, cannot now be carried any great distance from their sources, on account of the excessive expense of coolie and cart traffic. . . . In 1900 a severe drought destroyed the crops in Shen-si province and soon reduced 3 million people to starvation. More than a third of these actually perished for want of food. And yet, at the same time, bountiful harvests were gathered in the eastern and southern provinces. . . . The coal from Shan-si, carried on donkeys or coolies, is doubled in price every 15 or 20 miles, and so can have only a local market. For this reason one sees the peasants of the great Yellow River plain burning corn-stalks for fuel in their cooking stoves and making no pretense of heating their houses during winter. Coal is beyond their reach now, but with railroads they might have an ample supply at $2 or $3 per ton."

Railway Building in China. The railroad will not drive out entirely the cart and the barrow, the donkey, and the coolie-porter. For the present it will merely supersede them in long-distance hauling. In time, however, the multiplication of branch lines will release millions of human freight carriers, who can turn their attention to production, while engines take care of the transportation.

China's first railroad was built in 1876 between Shanghai and Woosung, but it met with such popular resentment that it was torn up in the following year, and further construction did not occur until the end of the century. Most of the early lines were established in "foreign spheres of influence," such as those built by the French in Yunnan, the Germans in Shantung, and by the Russians and later by the Japanese in Manchuria. For years this unfortunate situation prevented the development of a unified railway system, but today virtually all railroads in China proper are owned and operated by the national government. An incipient rail net serves the eastern part of China between the Great Wall and the Yangtze Kiang. The old capital city of Peiping is connected with the nearby port of Tientsin, and lines radiate northeastward into Manchuria, westward into Suiyan, southeastward to the cities of Nanking and Shanghai, and southward to Hankow. Elsewhere most railroads are merely tentacles extending inland from the sea, such as the narrow-gauge line that runs from the port of Haichow to Sianfu in eastern

Shensi. As yet no direct rail route has been completed between Shanghai and Hankow, the New York and Chicago of China. Indeed, it was not until 1936 that Canton and a part of south China were linked by rail with Hankow and Shanghai. In China proper there are only 6,000 miles of railroad, or less than in our state of Georgia. Granted 25 years free of civil war and foreign invasion, China will undoubtedly build the railroads that she has needed for so long.

China Must Make Readjustments. China is on the eve of an industrial revolution whose effects may well be more far-reaching than any of her late political revolutions. Her newly found dependence upon world markets, after centuries of isolation and self-sufficiency, is already bringing about more rapid changes than did the introduction of the factory system in Great Britain. China is passing rapidly out of the domestic stage and is now taking millions of dollars worth of cotton goods and yarns, rice, machinery, metals, tobacco, illuminating oil, and every variety of manufactured goods. The rest of the world is taking from China her raw silk, beans and bean cake, oils, tea, tung oil, and various Chinese wares. Much of China's raw material goes to Japan.

When the Chinese may have finished their civil wars[7] and their foreign wars and are enabled to get at all their wonderful resources, utilize and transport them, still more surprising trade readjustments will follow, and China probably will enter an era of industrial and social problems more pressing than any nation has yet experienced. With the factory comes unemployment, a new thing of which the Chinese are already beginning to complain. Rapid railway building will give the freight advantages of competitive points. This is the force that has done more than all else to pile up Western populations in unwieldy cities, separate them from their food supplies, and increase the cost of living. The Chinaman who can live by the household system on his patch of ground will, like the New England farmer, often find that he cannot do so if he goes over to commercial agriculture with its freight charges and the limitations of crops to those that can be shipped. Yet China is getting railroads, the railroads make freight differentials, the freight differentials make cities, and the cities increase the cost of living by inflicting wastes which the richer West is with difficulty able to endure. The suddenness of these changes will make them especially hard on a people with such a low standard of wages and who, until the Japanese invaded their land, had such an undeveloped sense of united action for the common good. We Westerners know little of the real implications of the Chinese family system.

Transportation in Japan. Japan has had an unusual opportunity to develop water transportation—a string of narrow islands with rugged interiors that force the people to live near the coast, and the coast well supplied with harbors suitable for the much-used coasting vessels. This ease of communication has aided in the quick spread of Western knowledge. The transformation of Japan from a hermit nation with closed

[7] The history of China shows that a political breakdown with a decade or generation of civil war has been a recurring episode. It is one thing to have this in a self-sufficient domestic economy and quite another to try it in a trading economy such as the Machine Age produces.

ports in 1854 to a world power defeating the army and navy of Russia in 1905 seemed like a miracle. On December 7, 1941, Japan dared to attack the United States at Pearl Harbor, a fact that speaks eloquently of the growth of Japanese military and naval power. Throughout the present century Japan has been using every Western scientific device and has developed into one of the marvels of all times. It tells much of Japanese quickness, keenness, adaptability, energy, and power to imitate. The old hand industries have been laid aside or assisted by the machine industries. Japan reached the stage where she was importing raw materials and exporting her labor supply in the form of cheap manufactured goods. At the same time Japan built up a world-encircling merchant fleet and a large foreign trade, with the United States as her best customer (18% of the Japanese exports in 1939).

Japan's railway building has kept pace with her industrial and commercial development. With only 73 miles of railway in 1880, she had constructed 3,600 miles by 1900, and over 15,000 miles by 1939, most of it government-owned. It should not be overlooked that both topography and insularity combined to make the boat do the primary service to Japan and the railway the secondary service. Nearly all the important cities on the islands are connected by railway and ferry, while a seven-mile tunnel under the straits between Honshu and Kyushu unifies the transportation system. There is fast steamer service to the Japanese-built railway system on the peninsula of Korea, which connects with the Trans-Siberian through Mukden and Harbin, and with the Chinese roads by way of Newchwang. With her coasting steamers, ferries, and network of railways, Japan has the best and most modern system of communications in the entire Far East. What she will now, in defeat, be able to do with this equipment has become in large part a political question.

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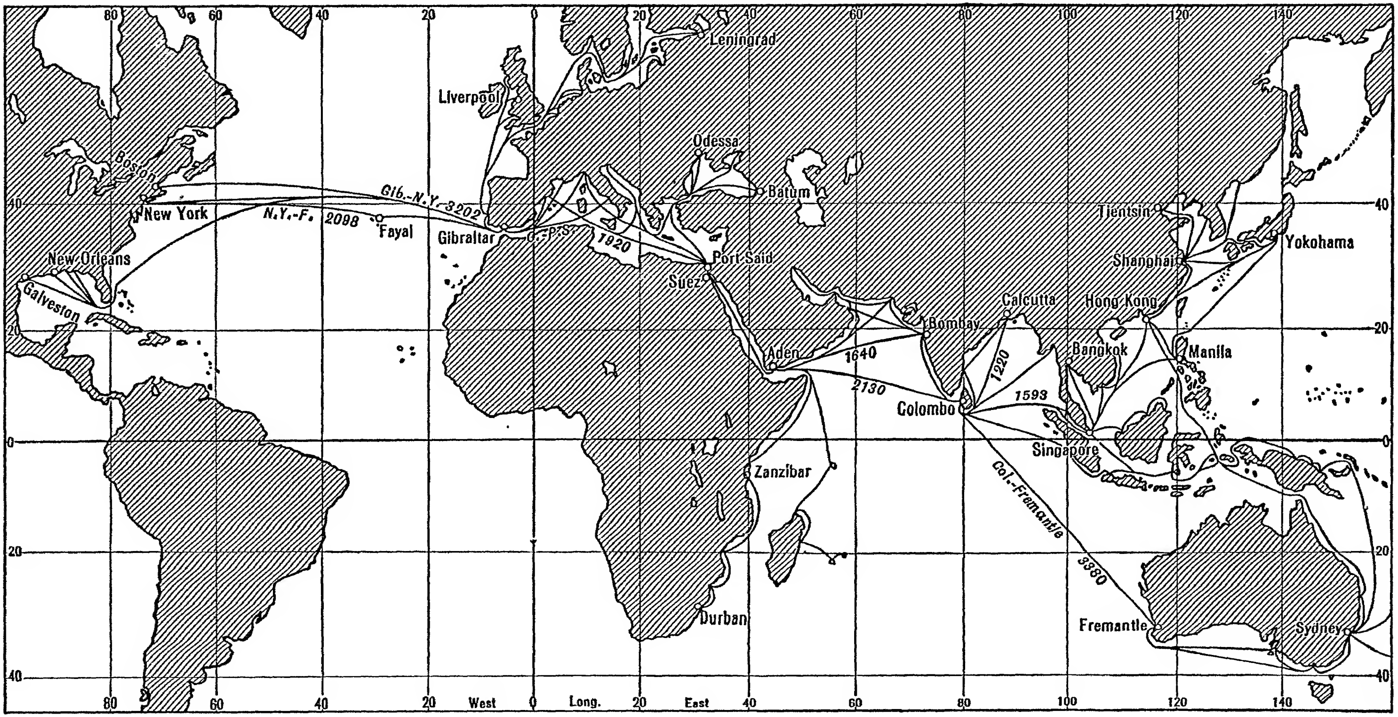
The Mediterranean-Asiatic Route

1. The World's Greatest Trunk-line Route

The Lands and People Served by This Route. This great trade route connecting America and Europe with Asia by way of the Mediterranean and Red Seas is the route through the heart of the world. It passes through the heart of the world in several senses: First, in point of land mass served by it. The world is often shown divided into two hemispheres, one of which is called the land hemisphere, with its center in western Europe and including practically all of the eastern hemisphere except Australia and nearly all of the western hemisphere. The major parts of this land hemisphere are connected through their midst by this great route and its main ramifications. An examination of the globe shows how great a part of the world it reaches. Asia itself comprises more than a third of the land surface of the earth. With Europe and Africa, which are a part of the same land mass, it comprises much more than half of the earth's land; Mackinder calls it the World Island.[1] By one of the fortunate circumstances of geography, this route pierces the middle of this world island and land hemisphere and practically circumnavigates the vast irregular continent sometimes called Eurasia—much the greatest block of land in the world—and receives branches from all of the numerous indentations that cut its southern shore. The vast size and mountainous interior of these lands reduce land transportation to insignificant proportions and turn all traffic toward the sea.

In a second respect this route may be said to pierce the heart of the world, because it reaches lands containing most of the world's population. The great land mass of Eurasia has about 1,730 millions of people, Atlantic North America has over 130 millions, and Africa contributes enough to raise the total of the people served by this route to well over 1,800,000,000—an astounding figure. The total population of the world is about 2,200,000,000, so that the Mediterranean-Asiatic route serves more than three-fourths of the world's inhabitants. The only large masses of population that are not reached are the almost self-sufficing primitives of Africa and the eighty-odd millions of South Americans, so that the Mediterranean-Asiatic route not only reaches the major part of the world's people, but a still greater proportion of the world's so-called civilized people. It connects with two great types of Western civilization, as represented by Europe and America, and the Orient, with its older civilizations of India, China, and Japan. Along the route is found every stage of industry

[1] See Halford J. Mackinder, *Democratic Ideals and Reality,* Henry Holt & Co., 1942.



This route has the perfect development—a main trunk with branchings at each end, like the roots of a tree or the branches of a tree. At each end they might be called either roots or branches.

from the most complicated and mechanical in America and Europe or the most elaborate hand manufactures of India and the Orient, to the crudest producers of crude raw materials such as the salt gatherers on desert coasts.

History of This Route and Its Trade. The route, in that it includes an artificial ship passage from the Mediterranean to the East, is a creation of the most modern civilization; but the trade is older than the Pharaohs, for the trade is that between the West and the East, regions which have, since before the dawn of history, differed as they do now in the general conditions of life and production. The silks, perfumes, spices, and other costly products of the tropics and of Asiatic skilled hand labor have for fifty centuries come out of the Far East and sought Europe. This destination has been reached over a multitude of routes from the Trans-Siberian sledge route in the frozen north to the galleons which rounded the Cape of Good Hope. Between these two extremes the route of this traffic has shifted, and with every shift it has made a new epoch in history. There were times when it came to the north of the Caspian Sea through south Russia and Poland into east Germany; again it sought the same route to the Caspian and passed into western Europe through the Danube Valley. For a time it went to the south of the Black Sea across the Bosporus and made Istanbul the commercial mistress of Europe. A yet more southern route is that connecting the Persian Gulf and the northeastern end of the Mediterranean where the city of Antioch grew into prominence. In the sixth century it made great the desert cities of Baalbek and Palmyra. The region around Suez has had its share of the traffic in ancient times. Caravans have sometimes crossed the short Isthmus of Suez; at other periods they have even reached the Nile Valley below Cairo. From 1500 to 1840 nearly all of this traffic passed around Africa in sailing vessels. About the middle of the nineteenth century the Peninsular & Oriental Steamship Line had its origin in steam services which gave a mail route from England to India through the aid of separate lines of steamers running from Great Britain to Egypt and from India up the Red Sea to Port Said. The portage where the Suez Canal now gives a through passage was then a busy place. At times 3,000 camels were employed to carry a $2,000,000 cargo of a single steamer across the isthmus.

The opening of the canal in 1869 made a great revolution in trade, not only in the route it could follow, but in the type of vessels to be used. Because of the uncertain and weak winds of the Mediterranean and the yet more uncertain winds of the narrow, rocky, and dangerous Red Sea, the canal was of little use to the sailing vessel. The opening of the canal, therefore, meant both a new route and a new type of vessel, to be built for the Suez Canal trade.[2] The traffic rose slowly at first, but it has,

[2] The first ocean-going steamers were liners, and as the steamship invaded one route after another, the sailing vessel disappeared from regular line service. While a few steam tramps were used as early as the Crimean War on the short routes around the European continent, it was the opening of the Suez Canal that gave the first great impetus to the construction and operation of tramp steamers. The new trade through Suez called for a cargo steamer of moderate dimensions, able to visit a large number of ports under diverse conditions, easy to handle, economical to operate, and capable of carrying heavy and bulky commodities. Competition from the dependable tramp eventually caused the sailing vessel to disappear from one tramp trade after another. The Cape of

ships to the Orient must round. Exactly on this point is Singapore, a port of admirable location for a coaling station and also with cheap coal supply, due to the fact that it has available for shipment full cargoes of Malay copra and iron ore and that it lies relatively near the great rice ports of Burma, Siam, and French Indo-China and the sugar ports of Java, so that vessels coming with coal from Australia, from Japan, from India, have excellent opportunities to secure return cargo.

It is interesting to note that this port of Singapore is purely a creation of the present Mediterranean-Asiatic route. In the sailing vessel days that strait was of little importance. The vessels from India sailed south across the Indian Ocean; those from China and Japan came down the China Sea and through the Sunda Strait separating Java and Sumatra. Under these conditions of ocean transportation Sunda Strait was the gateway to eastern Asia, and Batavia, lying almost at the mouth of the strait, was the great port. With the coming of the steamer passing westward to the Suez route, all this was changed and the Strait of Malacca, between Sumatra and the Malay Peninsula, became the gateway to the Far East. In 1819 Stamford Raffles, a British subject who could foresee the future, calmly and daringly seized the island of Singapore which guarded this passage and then persuaded a Malay sultan to cede it to the East India Company. His commercial and strategic foresight have been well indicated by the progress of the last half century, which has made a great port on this island and put Raffles' statue in the central square which bears his name. During this time the port has become the greatest of the region, a great but not impregnable British fortress, and a great commercial coaling station for the shipping of the world. Other coaling stations of importance are Hongkong and Shanghai.

There is no iron-clad rule by which a shipowner decides the actual coaling practice to be followed by the captains of his ships, because it becomes a new business question with each voyage. If the ship can make its owner more money carrying much freight and little coal, it will do so and stop at frequent intervals for more coal. If such stopping is desired, no long route in the world equals this one for coaling opportunities. A vessel can sail over it from the remotest port in the Gulf of Mexico to Vladivostok in east Siberia without ever being compelled to carry coal for a voyage longer than that between Aden and Colombo, a distance of less than 2,200 miles. The vessel from the Gulf of Mexico, if it so desired, could get coal at Norfolk or Bermuda; the vessels from New York occasionally in times of great stress of freight and high rates call at Fayal or St. Michaels in the Azores about 2,000 miles out from New York; and thence onward the succession of coaling stations is continuous. The leading ones actually used by the various lines are Gibraltar, Algiers, Port Said, Aden, Colombo, Singapore, Hongkong, Shanghai, and Yokohama or Moji.

The coaling question may sometimes assume another aspect to the shipowner. If freight rates are low and the amount of freight scanty, for the two usually go together, the cost of frequent stopping at coaling ports may make it unprofitable. In every case there are port dues to pay, usually a high price for coal; there

is always loss of time, and usually quarantine expenses, pilotage, and the possibility of quarantine delay. For these costs there are in times of low freights no compensating returns, and it will therefore pay the steamer to carry as much coal as possible from the original port, as in cases where vessels are known to have steamed without stop from Great Britain to Japan. This is, however, unusual, although the reduction of the stops to two, one each at Singapore and Port Said, the best ports, is not uncommon. It is probable that the coal supply of China may in the near future materially alter the coal supply of Oriental ports.

Already a great change has come about in fueling practice along this route due to the fact that more than a half of the world's merchant tonnage now uses oil as fuel instead of coal. Virtually all liners are oil-burners or Diesel-engined ships. These vessels have a longer operating radius and do not have to stop so frequently for bunker fuel. With the exception of its extremities in northwestern Europe and eastern Asia, the Mediterranean-Asiatic route is well supplied with petroleum. Eastern America and the Caribbean area produce about three-fourths of the world's petroleum and supply western Europe. The oil fields of Russia, Rumania, Iraq, Saudi Arabia, Bahrein Island, Iran, Burma, the Dutch East Indies, and British Borneo are adjacent to the route. As long as the petroleum supply remains plentiful and cheap, an increasing amount of it will be used for ship fuel.

A Trunk-line Route. Of all the world's ocean routes, the Mediterranean-Asiatic is the trunk line par excellence. This comes about from its length and its location between the two northern and the two southern continents of the eastern hemisphere, which it serves by numerous lateral branches, finally reaching in the west the United States, where its termini include the widely separated points of Houston and Boston. The indented coasts of Europe and Asia furnish from every great gulf and sea a branch to the main trunk route (see Fig. 831). In this respect it is quite the peer of any railroad system and in its structure bears considerable resemblance to the Pennsylvania Railroad—probably the best located railroad with regard to freight traffic in the whole world.

2. *Six Major Traffic Divisions*

Traffic. The traffic upon this great route, which almost circumnavigates the world, is as varied as the peoples and lands which it reaches. For convenience the traffic may be considered in six different groups. While two of these groups are confined to a single continent each, and in that respect have certain local aspects, their trade is international.

First—Traffic of the Mediterranean Waters. The Mediterranean itself is about 2,000 miles long; and, including the Black Sea, it is nearly 3,000 miles from Gibraltar to the most remote indentations of Soviet Russia. This may properly be called the most magnificent system of "inland waterways" in the world. Its waters give ocean transport to a dozen independent countries and many colonies. Through the navigable rivers of south Russia and the great Danube, it reaches far into the heart of Europe. From prehistoric times it has

been the scene of busy commerce. Before the days of the compass its many islands favored navigation from landhead to landhead, and it is thus possible to traverse its whole length with reasonable safety by keeping in sight of land. In the present epoch of steamers it is busier than ever. A good example of this is one Italian steamship company, which before World War II possessed over 100 steamers and served some seventy-five ports on the Mediterranean system. These disbursers of Italian produce and collectors of Mediterranean goods gather products at Genoa and Naples to be sent across the Atlantic in ocean steamers belonging to the same company. This is a common system in European commerce and in the Mediterranean. It is also done by the French lines assembling at Marseilles, and, to a lesser degree, by the Spanish, the Russian, and other steamship companies.

This Mediterranean traffic is between two distinct economic districts—a food-importing district and a food-exporting district. While Italy, France, and Spain are great agricultural countries, they are also manufacturing countries and must import both food and raw materials. The east Mediterranean region, comprising the nations of the Danube Basin, Greece, Turkey, and southern Russia, have a surplus of food and raw materials for export. Grain and other agricultural products are the chief exports, and to these, the east end of the Black Sea adds ores and the petroleum exports of Batum. This gives the basis for a lively exchange of manufactures from the west for the wheat, corn, rye, oats, manganese, and oil of the east Mediterranean.

Second—Traffic Between Western Europe and the Mediterranean. Great Britain and the other countries adjacent to the North Sea use great quantities of the sub-tropical orchard and garden produce grown along the shores of the Mediterranean proper, from Spain to Asia Minor inclusive. Chief among these products are wine, oranges, lemons, figs, raisins, olives, and early vegetables. These edibles in great quantities go to the northwestern countries, which are also large importers of North African phosphate, Sicilian sulfur, Egyptian cotton, Russian oil and manganese, and grain from the Danube and Black Sea region. The return cargoes in this trade consist in point of bulk primarily of coal of which about 10 million tons a year pass from the Welsh fields to the Mediterranean ports. The next in bulk are the forest products of Scandinavia which are in great demand in the populous and essentially timberless Mediterranean. In point of value these bulky articles are rivaled by the machinery, cottons, and other manufactures of Great Britain, France, Belgium, and Germany.

Third—Traffic Between the East Indies and the Orient. The term East Indies—following the British classification—includes India itself, the mainland to China; also Singapore and the adjacent islands. Here is a large traffic and one which promises to continue its growth, for it has a firm basis in economic conditions. Japan before World War II had become a rapidly increasing importer of food and raw materials. Chief among these imports were rice from Burma, Siam, and French Indo-China, raw cotton and jute products from India, sugar from Formosa and

Java, and iron ore from Malaya and the Philippines. In return for these commodities Japan sent coal as far as Singapore, and manufactures (chiefly cotton goods) to all the countries mentioned. If Japan resumes her industrial expansion, and China with her vast population follows in her wake, this trade between temperate Asia and tropic Asia promises to increase greatly.

Fourth—Traffic Between North America and the Mediterranean. This is, in its present routes, a new trade. There was a time not long ago when direct steamer lines from north Europe to America took from Europe the products of all parts of the world, including the Mediterranean. This practice of transshipping at Liverpool or London the products of Italy, Spain, Greece, Egypt, and Turkey has almost ceased since the establishment of direct steamship services between the Mediterranean and American ports, thus carrying one step further the universal desire for direct communication between producer and consumer. For example, long-staple Egyptian cotton is now carried on American ships from Alexandria directly to New York. From the Mediterranean region the United States imports such products as olives, olive oil, wine, raisins, currants, and sardines in addition to considerable quantities of Portuguese and Spanish cork, Spanish fluorspar, pyrites, and iron ore, Egyptian cotton, and Russian manganese. In volume and weight these imports greatly exceed our exports, which consist chiefly of machinery and other manufactures and cotton,

Fifth—Traffic Between Europe and the Orient. This is really the first and greatest of them all. In its beginning and down to comparatively modern times this trade was chiefly an exchange of European bullion for the silks and other luxuries of the skillful East. The easy transportation of the steamship era has added to it commodities which before were unthought of. The region of the Persian Gulf now sends to Europe dates, wool, hides, and oil, as well as Mohammedan prayer rugs. The port of Karachi in northwestern India was famous for huge shipments of wheat, but this trade has now dwindled to less than 3 million bushels a year. Beyond is Bombay, which sends to Europe cotton, wheat, and a great variety of oil seeds including peanuts, castor beans, and linseed, which have many industrial uses. Vizagapatam on the east coast is one of the world's largest shippers of manganese ore. Beyond is Colombo in Ceylon, which, along with Calcutta, has become a great exporter of tea. From Calcutta also comes the world's supply of jute for bags and burlaps, and also much hemp and coir fiber. Indo-China, which may for this purpose be considered to include Burma and Siam, also has its staple export, rice, which is sent in shiploads to Bremen and London, the great European rice markets. Singapore is the assembling point for the world's crude rubber, a shipper of tin, and a great spice center. It is also an entrepôt center and a junction point for many steamship lines, and has a foreign trade varying from $400,000,000 to $1,000,000,000 a year, greater than that of many nations. From Java come annually a million tons of sugar more or less. The Philippines send Manila hemp, copra, and coconut oil. China and Japan are the main factors in the world's supply of raw silks

and compete with India in the export of tea.

In return for this varied supply of raw materials and peculiar manufactures, western Europe (chiefly Great Britain) is sending iron and steel products, locomotives, all kinds of machinery, cotton goods, clothing, chemicals, and manufactures and supplies in innumerable variety.

Sixth—Traffic Between North America and East Asia. This was, at one time, very much like the trade from the Mediterranean in that little of it was handled by vessels passing directly between the trading countries. London was the great entrepôt center from which we received the products of all Asia, and the returning European vessels carried some American goods, although much of the American supply of goods imported from Asia was paid for with European manufactures, which in their turn were paid for by our exports to Europe. About 1900 direct lines of steamers were established between New York, India, China, and Japan. The experiment was instantly successful, and the lines have continued, with the addition of others from the Gulf ports. These vessels carry cotton, petroleum, sulfur, phosphate, wood, and steel manufactures, tobacco, cotton cloth, and miscellaneous manufactures. Illuminating oil was formerly so much prized by the Chinese that it filled quite the half of all the shipping from the United States to China, but there is a growing demand for our textile machinery, iron and steel products, locomotives, chemicals, dyes and textiles. The return cargo is generally less bulky and many of these vessels return with Philippine hemp and sugar, Malay and East Indian rubber and tin, or the rice of southeastern Asia.

Competitive Status of Tramps and Liners. Several important changes in traffic conditions occurred along the Mediterranean-Asiatic route in the interim between World Wars I and II, most of them contributing to the decline of tramp shipping. First, there was a great decline in the importance of the "Big Triangle"—a lucrative trade involving the movement of tramps with coal from Great Britain out to Italy and Mediterranean coaling stations, on to the Black Sea in ballast, and back to northwestern Europe with grain. In the 1930's Russian wheat exports were less than one-third of their volume prior to World War I, while British coal exports to the Mediterranean area declined to about one-half of their former size. Second, American exports of cotton, wheat, and lumber declined sharply. Third, Indian wheat exports in 1930-38 averaged less than 3 million bushels annually, as compared with 50 million bushels in 1909-13. Fourth, liner shipping captured nearly all of the Indian jute trade and more than half of the Burma rice trade. Fifth, the sugar exports of Java came to be handled almost entirely by liners.

On the other hand, several developments provided new traffic for tramps. As a consequence of industrial expansion, Russia began to make large shipments of pig iron to Japan and railway materials to eastern Siberia from its Black Sea ports. India became the world's greatest exporter of pig iron, more than one-third of her output being shipped to Japan, Great Britain, and the United States. The greatest of all devel-

opments, however, favoring the tramp was the tremendous increase in soybean exports from Manchuria. Between 1911-13 and 1935-37 the average annual exports of soybeans increased from 196,000 to more than 2,000,000 tons. Approximately two-fifths of these soybean exports were carried by tramps from Manchuria to Europe, and many tramps were able to return directly to the Far East with full cargoes of German fertilizer salts for Japan.[3]

[3] See Franz Lohse, *Die Entwicklung der Trampschiffahrt in der Nachkriegszeit,* Dresden, 1934, and P. Schultz-Kiesow, "Organisation und Machtstellung der japanischen Trampschiffahrt," *Wirtschaftsdienst,* vol. 18, no. 12, Hamburg, May 12, 1933, pp. 624-628.

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The North Pacific Route

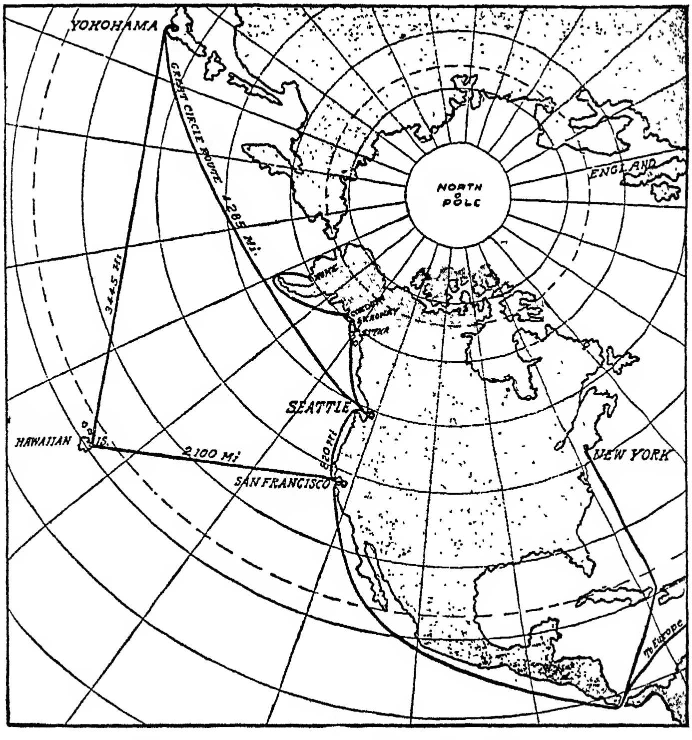
1. The Rise of North Pacific Trade and Shipping

The Commercial Newness of the Pacific. The Pacific Ocean is the last of the great oceans to become of interest to the world at large. The Atlantic and the Indian have been repeatedly traversed by the representatives of western civilization since the year 1500, but during three-fourths of the period that has elapsed since that date the Pacific has remained a region unknown; and at the opening of World War II there were uncharted islands in its vast expanse. When the eastern coast of North America had already produced commonwealths strong enough to declare their independence, the central Pacific was just being explored by its first great navigator, Captain Cook, who lost his life there at the hands of the islanders who had never seen a white man until Cook's motley crew appeared. About 1806 Oregon received its first white settlement, but as late as 1840 a man of international reputation stood up in the United States Senate and ridiculed the idea that the Pacific coast of what is now the United States could ever be of value. It is from the middle of the nineteenth century onward that the Pacific has risen swiftly to the important place it now holds in the attention of mankind. In 1846 we annexed California. In 1848 came the gold discoveries in California, and the making of a new commonwealth there promptly followed. Three years after the California discoveries the gold cry went up from Australia, and there was a rush to that corner of the Pacific. In 1854 the ports of Japan were opened to the world; fifteen years later our first transcontinental railway was completed to the Pacific coast; and since 1850 we have had continual interest in the north Pacific fisheries.

Since 1890 the intensity of interest in the Pacific has increased. In 1894 came the Japanese-Chinese War, which signified that there was an Asiatic power. In 1897 the Alaska gold discoveries were made. Upon the first of May, 1898, Dewey's guns announced from Manila to the American world that there were such things as the Philippine Islands. We have annexed Hawaii, have watched the Russian advance to the Pacific, and the resulting Russo-Japanese War. Meantime, all the leading powers of Europe attempted to gain a foothold in China, the mysterious Celestial Empire that has proved so inviting to the exploiting and trading nations. In 1914, after a decade of arduous digging, Americans opened a new gateway to the Pacific at Panama. This strip of water proved of priceless value three decades later when we were confronted with the gargantuan task of moving warships, troops, and supplies across the world's largest ocean in order to defeat Japan.

The Steamer Tracks. All the recent commercial interest centers around regions which are directly connected with the North Pacific trade route. This route is like the North Atlantic route in that the great circle factor is of much importance in locating it, and widely separated regions are brought by the factors of geography to use one and the same great route. The great circle factor is of much greater importance on the Pacific than on the Atlantic, because the regions of importance upon the two ends of the route are in virtually the same latitude; the distance is so much greater that the amount of the northern deviation of the great circle line is consequently increased. There is no trade route upon which the Mercator map works greater distortion. The American-Asiatic cable route via the mid-Pacific islands of Hawaii and Guam to Manila is far from the direct line, but was so placed to be on American soil.

Instead of America and Asia facing each other across a wide ocean, a globe shows that, because of the great width of the Pacific, the west shores of America and the east shores of Asia are practically a continuous straight line. This revolutionizes the ideas which one must get from looking at a flat map, especially the Mercator projection. The steamer that attempts to pass directly from the ports of Puget Sound to Yokohama will wreck herself upon the rocky

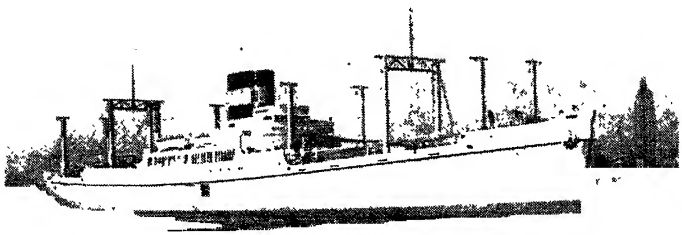


The maps we use make it hard for us to remember that the world really is a sphere, and these flat maps do much to hide real directions between places, especially places in high latitudes. The distances shown here emphasize that point.

shores of the barren Aleutian Islands Consequently the route is not a true great circle, but is flattened out to the southward from it, so that the vessels may avoid the Aleutian Islands, in sight of which they pass. From San Francisco it is possible for the vessels to make a true great circle up near the Aleutian Islands. The effect of the great circle becomes yet more perplexing when the attempt is made to apply it to the route from Panama to Yokohama. The direct line between these two points goes northwestwardly through the Caribbean Sea, Yucatan, the Gulf of Mexico, Texas, Wyoming, Vancouver Island, the Alaska peninsula and thence southward to Japan, a route available to an airplane but not to an ocean vessel. A steamer compromising with these hard facts skirts the shores of the American continent until southern California is reached, and then crosses the North Pacific Ocean in the latitude of southern Canada. San Francisco is therefore much more nearly upon the actual short route from Panama to Yokohama than is Hawaii, which we are accustomed to think of as being exactly in the path. To stop at San Francisco would require a deviation of but 114 miles from the shortest possible steamer path and the deviation to Hawaii is over 300 miles. The one point that commercially commands the North Pacific route is the main island of Japan, for upon it is the great port of Yokohama, where almost every vessel crossing the North Pacific stops. Here every thread of this great commercial cable is focused to a single point. This spot is exactly on the route and is a great coaling station, being thousands of miles from any other port to the eastward which can have rendered service to the steamer. Manila is the last port of call for the steamers passing from America to Asia; Yokohama is directly on the route to it; and the Chinese ports of Hongkong and Shanghai are almost invariably sought by the same steamers on the out voyage.

Owing to the storms of winter, vessels do not always go so far north at that time as in summer, but they never go far enough south to prevent their reaching Yokohama as their first port. The importance of the trade of the Hawaiian Islands causes the port of Honolulu to be visited en route by steamer lines making for San Francisco, although this detour costs these vessels about 800 additional miles of steaming. The vessels from Puget Sound to Asia do not touch Hawaii.

Fuel Supply and Winds. Upon most of the great trade routes there has been a sailing-vessel epoch, which has gradually given way to the advance of the steamer. There has been less of this upon the North Pacific than upon any of the other great routes, chiefly because most of the traffic has arisen since the epoch of the steamship, and, furthermore, because it is essentially steamer rather than sailing-vessel traffic. This part of the ocean, however, is well supplied with the natural conditions for sailing vessels. North of latitude 35° there is a good westerly wind blowing eastward from Asia. Most of the time, the westbound vessel would beat southward immediately upon leaving an American port; and when the trade-wind zone was reached, it turned westward and sailed before this wind for thousands of miles until near the coast of Asia; then a deviation was made to reach the desired ports.



One of the interesting trades of the North Pacific is the journey of Round-the-World vessels, which for many years have had their base at San Francisco and journeyed westward. Not long ago one of the captains of this company retired with the mild complaint that he had lost 79 days of his life in crossing the International Date Line going to the westward, a process which causes the ship's log to read somewhat as follows, "Monday, Tuesday, Thursday, Friday," Wednesday having been used up in pieces in daily adjustments of the clock to keep with the sun.

The coal supply upon the route is fairly satisfactory, and the great length of the voyage requires that a steamer shall give up a comparatively large proportion of her space for coal purposes. There is practically none taken en route. Fortunately the Japanese coal, lying as it does part way between Asia and America, is admirably located. A vessel a thousand miles out from the Chinese coast takes on Japanese coal very close to the point of its production. Unfortunately, there is no satisfactory supply thus far in California, and most of the American coal comes from the mines of Vancouver Island which yield less than 1½ million tons a year. Some Japanese and more Australian coal is imported at San Francisco, and for many years before the opening of the Panama Canal cargoes of coal in sailing vessels regularly came around the Horn from Atlantic ports of America and occasionally from Wales in vessels seeking wheat cargoes.

The ideal fuel on the North Pacific is oil, which is used entirely by liner shipping and to an increasing degree by modern tramps. Both the oil-burner and the economical motorship (Diesel) are able to travel long distances without refueling and are well adapted for service on the routes that span the world's largest ocean. In general, the North Pacific route is better supplied with oil than with coal. Fueling stations along the North American coast have easy access to Californian oil, huge quantities of which are shipped to Japanese and other Asiatic ports. Furthermore, eastern Asia normally receives much oil from the Dutch East Indies and some from the Russian-owned island of Sakhalin.

Early Traffic. The first part of the North Pacific route to attain modern importance was the link between Panama and San Francisco in the early days of the gold epoch in California. Many thousands of men engaged in producing nothing but the precious metal of coinage required a relatively great movement of commodities to supply their every want. For a time the returns of gold production were so great that it

paid to produce nothing in California, but import everything from other parts of the world. While the pioneers crossed the continent in stage coaches and wagon trains, sailing vessels flocked around Cape Horn with supplies, but this route was so slow and so long that means of communication across the Isthmus of Panama were promptly established; steamship lines were running from New York and San Francisco to Panama (and also to Nicaragua) several years before the opening of the Panama Railway in 1855. Over this route there was a lively trade, which increased steadily until the completion of the Union Pacific in 1869 furnished speedy railway communication with the eastern centers of population.

The North Pacific route has rendered its greatest service as a new road between the West and the East—a new rival to the old routes across Asia, around Good Hope and through Suez. Before the first transcontinental railway was opened in 1869 there was a steamer line from San Francisco to Japan and China. This original line has been followed by many more.

2. *Present and Future Traffic*

Predominance of Westbound Cargo. Traffic on the North Pacific route may be divided into two major streams. The first and more important consists of vessels operating between the west coast of the United States and Canada and the countries of eastern Asia. The second consists of ships that operate between our Gulf and Atlantic ports and the Far East via Panama and which call at our west coast ports en route. In each case the tonnage of westbound cargo far exceeds eastbound.[1] The reason is obvious. Vast quantities of lumber, wood pulp, paper, scrap metal, and usually wheat and flour are shipped to eastern Asia from Washington, Oregon, and British Columbia. California's great export is oil, which is carried almost entirely by tankers, but California also provides such dry cargoes as scrap metal, fertilizer, cotton, canned fruit, and salt. From our Gulf ports are shipped large quantities of cotton, phosphate, sulfur, and some scrap metal, while our Atlantic ports export scrap metal, heavy iron and steel products, and a wide assortment of manufactures. In contrast, Philippine copra, sugar, hemp, and vegetable oils, Manchurian soybeans, and Chinese tung oil are about the only bulky cargoes moving eastward. Virtually all other eastbound commodities occupy little cargo space, such as silk, tea, cotton fabrics, drugs, lacquer ware, art goods, toys, and firecrackers.

As a consequence of poorly balanced trade, a large portion of cargo space on eastbound liners must move in ballast, a condition leading to higher rates and heavy governmental subsidies. The tramp, not being attached to any route, can carry cargo westward and does not have to return directly to North Ameri-

[1] In 1936, a year of moderate business activity and preceding Japan's invasion of China proper, our Pacific ports shipped 6 times more cargo, on the basis of weight, to East Asia than they received. At our Gulf ports the ratio was 5½ to 1; at Atlantic ports, 4 to 3. In years of greater prosperity, as in 1929 and 1938, the predominance of westbound cargo was even greater.—For detailed accounts of trans-Pacific trade and shipping, see Walter A. Radius, *United States Shipping in Transpacific Trade, 1922-1938,* Stanford University Press, Stanford University, Calif., 1944, and Eliot G. Mears, *Maritime Trade of Western United States,* Stanford University Press, Stanford University, Calif., 1935.

can ports. However, liner competition was so keen prior to World War II that scrap iron and steel destined for Japan from all of our ports and the large lumber and small wheat exports from the Pacific Northwest were the only westbound cargoes that were handled predominantly by tramps. In all other trades the liner reigned supreme, although tramps were used to carry about one-third of the fertilizer shipments from our Gulf ports, more than two-fifths of California salt, and about one-fifth of the wood pulp from the Pacific Northwest. In the eastbound trades tramps found some employment in the carriage of Manchurian soybeans and Philippine sugar, copra, and hemp, but most Philippine exports were handled by liner companies which would usually augment their fleets each year by chartering tramps following the sugar harvest season.

Hawaiian Traffic. The Hawaiian Islands have a place in the traffic of this route much greater than their area would indicate. The Hawaiian staple is sugar, stimulated by the tariff, the crop now averaging about 900,000 tons a year. Some of it now reaches our Atlantic ports by way of the Panama Canal, although most of it goes to the nearby ports of the Pacific mainland, which are also importing bananas, pineapples, and other tropical fruits from these islands. The frequent service from San Francisco makes that city an important base of Hawaiian supply as well as a market for Hawaiian goods.

Alaskan Traffic. To the northward there is an additional stream of traffic, to supply the mining industries of Alaska. Vessels pass both from San Francisco and Seattle, although the latter, because of its nearness, has a larger trade and a route which lies largely within the shelter of the archipelagoes that skirt the shores in this region. The Alaskan ports of Juneau and Skagway are located on the mainland not far from Sitka, while Seward is the coast terminus of a 510-mile railroad from Fairbanks in the heart of Alaska. Another interesting bit of traffic is that arising from the salmon fisheries which dot the American coast from the mouth of the Columbia River to Bering Sea.

Prospective Traffic. The prospects are for great increase of traffic along the North Pacific route. Every region adjacent to it is, in the modern sense, in its economic infancy. With their development will come trade. Japan has entered upon a manufacturing epoch in which, like Great Britain, she must import both food and raw materials. There has already been a large trade over this route in carrying to Japan the machinery necessary for the development of these industries. This traffic will continue, with, of course, changes in the number and character of the commodities comprising it. In Manchuria is to be found the only underpopulated part of eastern Asia suitable for the support of a large population. Adjacent to it are over 300 million Chinese who have lived thus far by agriculture and household industries in a region whose coal and other mineral resources are good. Already millions of Chinese have moved into Manchuria. People are necessary to a great world market, and China has the people. China has enormous future possibilities for trade.

It is generally recognized throughout the United States that the whole Pacific coast region of this country and British

Columbia is capable of great development. The growth of transcontinental railways to connect it with the East has completely reversed the prophets of the 'sixties, who asserted that the heavily subsidized Union & Central Pacific Railway would never have sufficient traffic to make it pay. The rapid increase of these lines can be taken as a prophecy for Pacific trade, for every transcontinental railway has some kind of trans-Pacific steamer connections as its western terminus.

Prospective Port Changes. This great multiplication of railways and Pacific steamship lines has cut into the early predominance of San Francisco in this trade. This port had the first trans-Pacific steamship line and the first transcontinental railway; and, naturally, in that period she had no rivals. The present leadership of Puget Sound as the American gateway for the traffic of the North Pacific route does not mean that San Francisco is actually declining or is likely to actually decline in the amount of trade. It means that other trade is arising elsewhere and that San Francisco will have a smaller territory to serve, but, within the smaller territory, a steadily increasing traffic. For the time being, Los Angeles booms with its oil.

Upon the Asiatic side Yokohama, Kobe, Shanghai, and Hongkong promise to remain the great ports, while Manila at the terminus should have a steadily increasing trade. The northern ports of Tientsin, Newchwang, Dairen, and Vladivostok already have traffic sufficient to merit direct communications, as have the newer ports upon the American side and upon the North Atlantic trade route.

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South American Trade and Trade Routes

1. Basic Features

Environmental Barriers to Trade. The geographical conditions of this continent have opposed the development of commerce and commercial routes, and South America today rivals Africa in the extent of its commercially unpenetrated land mass. Like Africa, it forms a solid block of land with a somewhat regular coast line and a consequent dearth of good harbors, making poor facilities for the commerce of the sea to connect with the commerce of the land. When the land is attained, the trader finds access to the interior is difficult because a mountain wall surrounds the greater part of the continent. The Andes extend without intermission along the entire western coast. Upon the east the highlands of Venezuela and Brazil, although not so high as the Andes, bear much the same relation to a large part of the Atlantic side of the continent.

Further than this, it is difficult to reach the plateau because of the inhospitable nature of the coastal plain lying between the base of the plateau and the sea. From Guayaquil, 3° south of the equator on the Pacific side, around the northern and eastern parts of the continent to southern Brazil, the shore plain (nearly continuous) is almost uniformly forest clad, often low, hot, and marshy, infested with insects, and subject to malaria and other tropic diseases. This is a constant barrier to the growth of prosperous maritime cities and a hindrance to the conduct of commerce with the interior.

As a result, the ports are usually small cities, limited strictly to the purely commercial operations necessary to the handling of imports and exports. Another and usually much larger city is commonly nearby on the more healthful plateau. It is in reality another part of the same economic community. The city is merely divided, and only that part remains on the natural shore site which absolutely cannot go up to the more wholesome hills. La Guairá is the port for Caracas, ten miles away in the mountains. Santos is the great Brazilian coffee port, but São Paulo, forty miles inland on the plateau, is the real center of the region. Rio de Janeiro is an exception to the rule in that it is a large city, but Petropolis on the heights twenty-five miles inland is the place of residence for the leading citizens of Rio de Janeiro, including the official representatives of foreign governments. The situation in Santos was long graphically described by a local saying that the inhabitants were vitally interested in, and talked about, three things—the price of coffee, the rate of exchange for the fluctuating Brazilian currency, and the yel-

low fever which was rife upon the low and unwholesome coast until 1905 when the advancing science of sanitation practically conquered the disease. The climate of the coast has been a great drawback to the settlement of the continent by Europeans. If the eastern coast of North America had presented so unfavorable a front to the colonists, the progress of settlement and trade would have been delayed many decades, perhaps a century; for the reputation of the land might have been made by its coast, and colonization discouraged.

The coast of South America has still further drawbacks for commerce. The Pacific shore plain from northern Peru 6° South Latitude to 30° south is essentially rainless and desert, except where irrigated by snow-fed streams flowing across from the Andes. The only South American coasts offering ready access to European colonists lie between 30° and 40° South Latitude and include the agricultural region of Chile and the southern states of Brazil, Uruguay, and a part of Argentina. With the exception of the coffee plateaus near the tropic in Brazil, these are the only parts of the continent in which extensive colonization has occurred and where the European races outnumber the colored races. In many of the tropic American countries there is but a small percentage of white people, the great bulk of the people being of a racial mixture. In some areas six racial types are to be found: white, Indian, Negro, mestizo (Indian-white), mulatto (Negro-white), and zambo (Indian-Negro).

The Apparent Advantage of Rivers. The interior of South America, although cut off by the plateau, consists of a vast plain to which three great, navigable rivers give entrance, and apparent solution of transport problems. The Orinoco, the Amazon, and Paraná-Paraguay drain valleys whose extent and fertility are only equaled in the temperate zone by the Mississippi and the Yangtze. But owing to the floods, forest, malaria, and other disadvantages of the tropic lands, communities of Western civilization have been able to avail themselves of only a part of one valley, that lying along the southern or temperate part of the Paraná. No large tropic valley in South America has yet been settled in any modern sense. They have been explored more or less, some of them have settlements here and there, but most of the land is almost in a state of nature.[1]

A Continent of Short Trade Routes. As a consequence of the natural conditions outlined above, the commercial life of the continent, with a few exceptions, passes along a number of short routes that connect the centers of population near the coast with the common highway, the ocean. With the single exception of the rubber gatherer's boat on the upper Amazon, there is no South American counterpart for the long caravan routes that traverse the deserts of Africa or the plains of Asia; no counterpart for the long-drawn Trans-Siberian Railway; no transcontinental railway lines like those of North America; no daring schemes like the Cape-to-Cairo Railway of Africa. In mere weight of difficulty, however, the Andes Mountains are the greatest single barrier that modern commerce has assailed. Lacking

[1] See A. Grenfell Price, *White Settlers in the Tropics*, Special Publication No. 23, American Geographical Society, New York, 1939.

long routes, South American commerce gravitates by many short feeders to the ocean, the one great highway of commerce. Owing to the unorganized internal transportation conditions and the lack of routes for assembling and distributing, the continent requires for its commerce many more ports than does North America, Europe, or Asia. There is regular service between Europe and ports on the Atlantic and Gulf coasts of the United States. On the coast of Chile alone there are more than 50 ports that are served by foreign or coastwise vessels, and there are a dozen ports to which European steamers advertise a service. Other coasts are equally rich in places at which ships stop, although many of them are far from being satisfactory harbors. For every little port there is an inland route or routes, but many of them are as insignificant as the little-known ports they serve.

Foreign Termini of South American Trade. All South American routes alike have Europe and the United States upon their other ends, yet these regions are from 2,000 to 6,000 miles away (see Fig. 831). At the same time there is almost no trade with Africa just across the South Atlantic in one place but 1,600 miles away. Regions have nothing to exchange unless there is a difference in production and wants. This the two continents lack. They lie in similar latitudes, under approximately similar climatic conditions; there is no great difference in density of population or stage of cultural development. The economic basis for the exchange of products does not exist; therefore there are no trade routes. The whole trade in the South Atlantic is that passing between the temperate zones and the tropics and that passing between a manufacturing region and a region producing raw material. "Down to the sea and away to the north" might well be its motto.

2. *Caribbean America*

The Caribbean Sea. This body of water, called by the Germans the American Mediterranean, is practically surrounded by continental shores or strings of islands, and lends itself naturally to skirting voyages. As there are numerous small ports of call, liner traffic has been rather difficult and costly to operate, but the steady growth of Caribbean trade has led to the establishment of many direct steamship connections between Caribbean countries and the United States and Europe. The Caribbean countries, being alike in climate and resources, have almost no trade among themselves. By far the greater portion of Caribbean trade is with the United States. To this great market vessels carry large quantities of sugar, tropical fruit, and petroleum, and also coffee, cacao, fibers, hardwoods, and ores, and they return to the Caribbean with coal, lumber, meat, flour, and a wide assortment of manufactures. European exports consist of manufactured goods, very little British coal being shipped to the Caribbean area, with the result that at least 60% of all cargo space on outbound vessels is empty. While most European traffic follows the North Atlantic route, a number of lines follow a semi-circular route via the Azores. Thus, the vessels of one British line leave Southampton and call at the Azores, Barbados, Trinidad, Barranquilla, Cartagena, Colón, Kingston, Antilla, and New York, and then they retrace the route to Great

Britain, calling at the same ports but in reverse order. A Dutch line makes a similar circuit between Amsterdam and New York via the Guianas, Venezuela, and the lesser Antilles. As on most other routes, the competitive status of the tramp has declined. Tramps carry out about 90% of the sugar exports and bring in more than half of all American coal, but virtually all other dry cargoes are now handled by regular liners.

The Great Route of Colombia. In the north, the Magdalena River resembles in its service a trunk-line railway. The river itself is the trunk; and, in addition to its navigable branches, several short lines of railway are among its feeders. One of the distributaries of the Magdalena has been deepened, and ocean vessels now call at the delta port of Barranquilla, which has become Colombia's greatest seaport. The river steamboats are of the flat-bottom stern-wheel type used on the Mississippi. The total length of navigation on the river is 900 miles and on the branches 215 miles. Rapids at La Dorada, 592 miles from Barranquilla, make it necessary to use a railway for fourteen miles, after which boats are again used. The lower valley is a green and almost uninhabited tropic forest. The chief centers of Colombian population, agriculture, and mining are on the interior plateaus drained by the Magdalena, from which the short lines of railway and numerous pack trails make connection with the river steamers. At some rainy seasons these pack trails become impassable even for mules; and at best everything that is carried to many interior towns must, if it weighs over 100 pounds, go in sections on the backs of mules. Consequently the imports of many parts of Colombia, comprising as they do the whole list of goods required by a modern community from hoes to pianos, trolley cars, engines, autos, trucks, and mining machinery, still call for most skillful crating and packing, often in knock-down form.

The river Atrato, draining a deep valley to the west of the Magdalena, is navigated almost to its source; but the commerce of this marshy and exceedingly unwholesome valley is served by one or two small steamers setting out from Cartagena.

Colombia pays for her small import with coffee from the plateaus, gold and platinum from the mountains west of the Magdalena, and gums from the lowlands, bananas from the northern coast, where an American-owned steamship line calls for them at Santa Marta, and hides from the drier parts of the country.

The Routes of Venezuela, the Northeast Coast, and the Lesser Antilles. The center of Venezuelan population is on the cool plateau around Caracas, where there are modern highways and several short railways united into a system reaching the seacoast at the ports of La Guairá and Puerto Cabello. The territory served by these ports is of comparatively small area, and is limited to the highlands east of Lake Maracaibo, and north of the Orinoco Valley; but this district is the economic and political heart of the nation. Here are to be found rich coffee and cacao plantations, six of Venezuela's seven largest cities, and the chief market for foreign goods.

To the rest of the world, Venezuela is synonomous with oil, for this South American country is surpassed in output only by the United States and Russia. Nearly all of the oil is produced in the Maracaibo Basin, and the royalties

received from the export of oil give the Venezuelan government the highest public revenue per capita in South America. Because of a sandbar across the neck of Lake Maracaibo, it is necessary to ship the oil in shallow-draft tankers, drawing only 11 feet of water. These tankers wait for high tide and ride across the bar in fleets, carrying the crude oil to the big refineries on the nearby Dutch islands of Aruba and Curaçao or to the new terminal facilities on the Paraguaná Peninsula for transshipment overseas.

The longest trade route of Venezuela is that furnished by the Orinoco, which is navigable by river steamers for 1,500 miles. Unlike the Magdalena, the Orinoco is of minor commercial importance, for it serves a poor and sparsely populated grazing country. Ciudad Bolivar (pop. 25,000), 230 miles from the river's mouth, is the assembling point for hides, a few live cattle, egret plumes, and a little gold that are carried by steamer to Port of Spain, Trinidad, for transshipment to foreign markets.

At one time the famous asphalt lake of Trinidad provided a major item of Caribbean commerce, but asphalt from the oil refineries has reduced its importance. No product could be more conveniently placed for export than the asphalt of this lake. This unending supply is located so near the sea that an overhead cableway less than a mile in length carries it from its original location to the hold of the ocean steamer. In 1938, tramp steamers carried about 85,000 tons of asphalt to European and American markets. Far more important today are Trinidad's oil fields, yielding about 650 million barrels a year, the largest petroleum output within the British Empire. Gasoline, fuel oil, and other products of her petroleum refineries are now Trinidad's leading exports, followed in importance by sugar and cacao.

The Guianas, like Venezuela and Colombia, belong to the commercial circuit of the Caribbean. British, Dutch, French, and American lines carry bauxite, sugar, and other products to overseas markets.

3. *Atlantic South America*

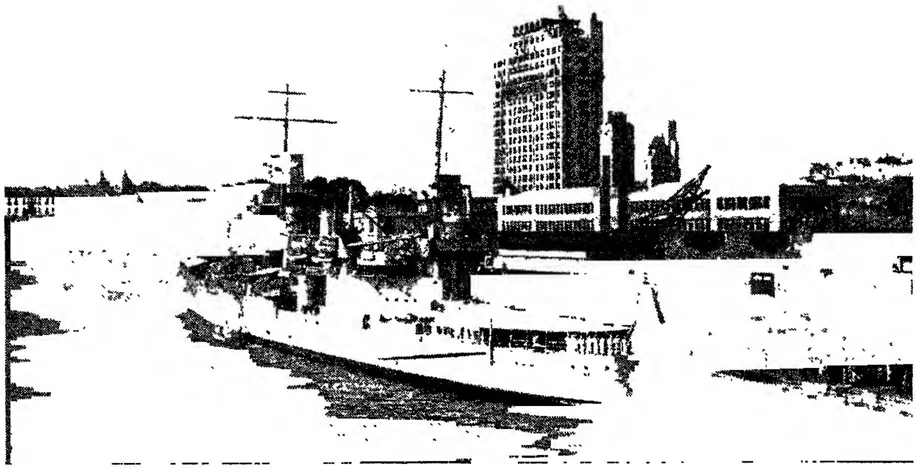
The Trade and Routes of North Brazil. From the Orinoco to Bahia, 13° south, there is a succession of ports, each the outlet for small coast settlements. Along the whole length of this coast, approximately 2,000 miles, there is but one route to the interior, the Amazon. This river and its branches afford a magnificent system of inland waterways running through a region almost entirely covered with forest and at certain seasons flooded many miles back from the streams. This valley, which might rival China in population if it were utilized, has a forest so exuberant that man has thus far used only a few of its by-products: carnauba wax, rubber, hardwoods, Brazil nuts, babassu nuts, tagua nuts, and balata, the total export of these commodities seldom exceeding $25,000,000 in value. The sickly population probably numbers less than one to the square mile. Ocean-going steamers from the United States and Great Britain regularly ascend the Amazon and its tributary, the Negros, to Manaus, a distance of 1,000 miles. Steamers of 15-foot draft traverse the river to Iquitos, Peru, while a number of navigable tributaries have steamer service for more than 500 miles.

There are many streams in the Amazon system that could be made navigable by the use of American "snag boats" such as are constantly employed in pulling logs and other obstructions out of the Mississippi River. Some authorities place the possible navigation of the Amazon Valley at 50,000 miles, but the part at present navigated is far below that. Thousands of miles of navigable waters are now given over to the crocodile and the occasional canoe of the native. Ecuador, Peru, Bolivia, and Colombia have trackless eastern territories in the Amazon Valley from which they have been cut off so absolutely that the Peruvian governor, if he does not travel by airplane, sometimes goes out to his post at Iquitos on the upper Amazon by way of Callao, the Panama Canal, and thence to New York, Lisbon or Liverpool before taking a steamer for Belem (Pará) and the Amazon River. The Amazon receives the commerce of a considerable region in eastern Bolivia, since the completion of the only important improvement on the whole system, 225 miles of railway connecting the navigable lower Madeira with its Bolivian branches above the 19 cataracts. It is estimated that there are 3,000 miles of navigable rivers in the Bolivian plain, a region that has been greatly isolated from the Pacific by the Andean wall.

The region between the Amazon and Rio de Janeiro is an exporter of sugar, cotton, tobacco, cacao, and hides. Here the Negro and the mulatto predominate. After the Amazon, the next in length among Brazilian inland trade routes is that from Bahia to the upper course of the San Francisco River. Bahia is the center of an important coast district and the terminus of a railway 300 miles long connecting with the steamers on the San Francisco above the falls that break its lower course as it descends from the plateau. This inland waterway is navigable for about 700 miles during the rainy season, but the rainfall, the population and the commerce of the upper valley are slight. The greater part of the commerce of Bahia has its origin in the coast districts. Recife (Pernambuco) is another important port of a coast section much like that about Bahia.

The Railway Net of the Coffee States. The greater part of Brazil's foreign trade flows through the two ports of Rio de Janeiro and Santos, the chief ports of Brazil and the ocean termini of the trade routes over which passes Brazil's leading export, coffee. Brazil's rubber district and her coffee district are farther apart and more thoroughly separated physically and commercially than the Washington wheat country and Alaska. The Brazilian coffee district occupies a broad plateau and has a railway system which has developed into the only railway network anywhere in the tropics outside of India. It has outlets at the two ports, Rio and Santos. These roads also carry raw cotton and manganese ore; and the traffic on the Santos line has made it necessary to double-track the road from the port to the inland metropolis, São Paulo, which is a city European in population as well as in appearance, being largely inhabited by thousands of recently arrived Italian immigrants. The extremities of this Brazilian railway net reach by devious routes points as far apart as Cleveland and Columbus, Ohio, are from Philadelphia and Baltimore, and one line now goes all the way to Corumbá on

All land more than ten miles from a railroad line is black. These black areas give a graphic measure of the lack of economic development of the continent of South America in the modern sense.



By Ewing Galloway, N. Y.

Rio de Janeiro harbor, with an American naval vessel in the foreground. Brazil resembles Canada in having vast areas of the interior almost uninhabited and completely undeveloped, while better areas more accessible and more suitable for Europan occupation have metropolitan cities of the European type. Rio is one of the world's brilliant cities.

the upper Paraguay. As this plateau produces nearly two-thirds of the world's supply of coffee, and as the United States is the greatest coffee-consuming country, the commercial relation between that country and Rio and Santos is heavy, though one-sided. We import Brazilian coffee by the tens of shiploads, but export to Brazil by the shipload, so that the balance of our trade is against us. (United States imports from Brazil, 1938, 101 million dollars; exports to Brazil, 72 million dollars.) On the other hand, we export to Europe much more than we import, while Europe manufactures the kinds of clothing and luxuries required in Brazil, so that the result is a curious triangular trade whereby Brazilian coffee goes to the United States and the United States pays for the coffee with cargoes of agricultural produce and manufactures sent over the North Atlantic trade route. Europe, in turn, pays for the American cargoes by sending shiploads of manufactures to the Brazilian coffee growers. Rivaling coffee in bulk though not in value is the coal import of about 1½ million tons, chiefly from Great Britain. In the early years of the present century tramp ships enjoyed a lucrative triangular trade carrying coal out from Great Britain to Brazil, coffee to the United States, and returning to Europe with a cargo of grain, lumber, cotton, or some other bulky commodity. For more than 25 years, however, almost the entire coffee trade has been handled by liners, and only occasional shipments of cotton, sugar, oilseeds, and ores have moved by tramp.

Southern Brazil. If we remember that Buenos Aires is in the latitude of Norfolk and that Rio is in the latitude of Havana, we will be better able to appreciate what southern Brazil is—a land with possibilities much like those of our own Cotton Belt. The chief new things

that are happening there are corn, meat, and lumber. American packing plants have arisen at Santos and other Brazilian cities, and the list of Brazil's exports had in 1938 an order that will surprise those who have not watched the changes come: coffee, 133 million dollars; raw cotton, 54 millions; oilseeds and oil cakes, 13; cacao, 12; hides and skins, 12; oranges, 7; carnauba wax, 6; refrigerated meats, 5; tobacco, 5; timber and lumber, 4½. The little port of Paranaguá is South America's leading exporter of timber, excellent pine, most of which is destined for the treeless Argentine pampa. Various European lines call at the southern Brazilian ports of Paranaguá, Pelotas and Rio Grande en route to, or coming from, the Rio de la Plata, the most prolific source of cargoes in all of South America.

The Rio de la Plata System. The busiest waterway in South America is the Rio de la Plata System, consisting of the Plata estuary and the Paraná-Paraguay and Uruguay rivers. Through the Plata estuary moves almost all of the overseas trade of Argentina, Uruguay, Paraguay, and a part of southern Brazil. Buenos Aires and Montevideo on the estuary are the dominant ports in this trade, but many ocean tramps and refrigerator vessels ascend the Paraná to Rosario, about 200 miles above Buenos Aires, and to Santa Fé, 50 miles farther upstream, for cargoes of grain and meat destined for Europe.

The main trunk-line river route extends up the Paraná and its tributary, the Paraguay. This route is navigable by 1,000-ton steamers during 3 months of high water as far as Corumbá, Brazil, 1,700 miles from Buenos Aires. Some 1,500 steamers call at Asunción, Paraguay, each year. The downstream movement of pine lumber, quebracho logs and extract, yerba maté, hides, meat, tobacco, oranges, vegetables, and Brazilian manganese is much heavier than the upstream movement of manufactures. This fact, coupled with a virtual monopoly of river shipping by a British company, makes freight rates high.[2] Indeed, it commonly costs more to ship products 1,000 miles from Asunción to Buenos Aires than from Buenos Aires to Europe or the United States. In spite of high rates and although the Paraná touches only the edge of Argentina's fertile and productive pampa, the Paraná-Paraguay has a flourishing trade.

The upper Paraná has little traffic above Encarnación, for it traverses a sparsely populated territory and is broken by great waterfalls. The Uruguay River, emptying into the Plata estuary, serves both northeastern Argentina and western Uruguay, and most of its traffic occurs below the meat-packing center of Paysandú. The little country of Uruguay, pastoral and wealthy, depends chiefly upon the four railroads that radiate from Montevideo.

The Railway Routes of Argentina. The most intensive railway development in the southern hemisphere is found on the fertile Argentine pampa, where a dense railweb fringed by a thin railnet covers 100,000 square miles, extending from the Atlantic coast westward to a frontier of aridity, about 64° W. Long (see Fig. 875). Railway construction on the level, stoneless, floodless, and virtually snowless pampa was

[2] See Ray H. Whitbeck and Frank E. Williams, *Economic Geography of South America,* McGraw-Hill Book Co., Inc., New York, 1940, pp. 234-235.

easy, although rails, ties, rolling stock, and fuel were imported from overseas and ballasting material had to be hauled great distances. On many lines there is not a single cut, fill, or bridge for miles. Furthermore, the pampa is easily served by railroads, for this great traffic-producing area is compact and near the sea. The pampa occupies less than one-fourth of the nation's area, but it contains three-fourths of Argentina's 13½ million people, four-fifths of the cultivated land, three-fourths of the manufacturing, and three-fourths of all railway mileage. All of the leading railway systems and their huge traffic in grain and animal products focus upon the great port and capital city of Buenos Aires (pop. 2,500,000), with Rosario and Santa Fé on the Paraná and Bahia Blanca on the coast serving as secondary ports.

Elsewhere in Argentina railway density is low, rail tentacles extending into the Chaco lands of cotton and quebracho and westward to the irrigated oases with their wine and sugar industries near the foot of the Andes, while in bleak and sparsely populated Patagonia only two lines reach inland from the sea. Although railroads now link Buenos Aires with Montevideo, Rio de Janeiro, Asunción, and La Paz, and while the Trans-Andean Railroad climbs to an elevation of 10,452 feet to provide through service to Santiago and Valparaiso, through freight on these international routes is negligible, and passenger traffic is small. Twice a week excellent trains make the trip from Buenos Aires to Valparaiso in 36 hours, but the Trans-Andean Railroad is steadily losing its passenger traffic to the more convenient airplane. The railroads mean much to Argentina, for outside of the province of Buenos Aires the highways are very poor.

The Overseas Trade of Argentina. The Paraná Valley and the Argentina plains are agricultural in the American sense. They are exporters of grain and animal products. They began commerce as a pastoral region, exporting such produce as hair, wool, hides, tallow, and bones. Later these fertile plains became a great exporter of wheat, corn, linseed (from flax), oats, and barley. Meanwhile the production of animal produce is in no wise diminished. Here, in this remote corner, where animals were so cheap as to be slaughtered for their hides, tallow and bones, the great firm of Liebig began then to make meat extract, a product requiring a minimum of transportation. It was the development of refrigeration that made possible the export of beef and mutton on the long ocean routes through the tropics to the great urban markets of northwestern Europe, with the result that shipments of livestock greatly declined. Argentina is a rival of the United States, having nearly as many sheep and about half as many cattle and an insignificant home market. Argentina ships in most cases to our market, Europe, the same farm products we export to it. On the basis of weight, Argentina has far more to ship to Europe than she receives. Hundreds of tramp ships call at Argentine ports every year for full cargoes of grain, linseed, and also hides and skins. On the return voyage they carry coal from Great Britain, amounting to about 3 million tons a year. The exchange of Argentine grain and British coal continues to remain one of the greatest of all tramp trades. However,

many tramps must leave northwestern Europe in ballast, and the out-freights are often so cheap that even bricks are carried to the southern hemisphere. Argentina's exports of meat, butter, and cheese are handled by refrigerator vessels, while wool, flour, quebracho extract, and most other commodities move by combination passenger and cargo vessels or general cargo liners.

Although commerce is predominantly with Europe, there is a basis here for American trade. We are importers of wool, skins, hides, linseed, and quebracho; since Argentina has become an agricultural country, and consequently an importer of agricultural machinery, in the manufacture of which we lead the world. Our steamship lines to Argentina, although less numerous than those of Europe, are prospering.

The southern part of eastern South America takes part in another triangular vessel movement. Argentina exports more in bulk and value than she imports. South Africa imports much more in bulk than she exports. Tramp vessels that discharge at Capetown, finding no cargo there, often swing across the South Atlantic to the mouth of the Plata, load a return cargo for Europe, and join the great procession northward bound along the coast to Cape São Roque where the Europe- and America-bound ships separate.

South of 40° South Latitude, South America has no important trade routes. It is a region which but a little while ago was called Patagonia, and was left as the unchallenged and unexplored domain of wandering natives, but which has been converted into sheep ranges to the great sadness of the persecuted native who had erstwhile lived largely by hunting wild guanaco, a sheep-like animal. The only ports of importance in this region are the Argentine port of Gallegos on the South Atlantic coast and the Chilean port of Puntarenas (Magallanes) on the Strait of Magellan. Both of these towns have meat-packing plants and are the bases of supply and export for hundreds of miles of coast, exporting the products of sheep ranches and some gold mines.

4. *Pacific South America*

The Trade of the Pacific Coast District. The western or Pacific side of the continent, because of the narrowness of its plain, and difficulty of travel in its slope, has a multitude of small and often inferior ports. In 4,000 miles there are but six railroads that cross so much as one range of the Andes; only five railroads reach the plateau, and only two cross it to the east slope. Few coasts are so devoid of back country. There is not in this whole length of the continent even a second-class navigable river, and only in part of Chile and in western Ecuador is there any valley worthy of mention. The agricultural region of Chile lying between 30° and 40° south consists of a long narrow valley between the Andes and a low coast range in which frequent breaks give access to the ports of the Chilean coast. The valley resembles exceedingly the valley of California, and its chief seaport is Valparaiso.

The Railroads and Ports of Chile. The long and narrow shape of Chile has given the country an unusual railway pattern (see Fig. 875). In contrast with Argentina, where railroads spread out like a fan from Buenos Aires, the

Chilean railway system resembles a centipede with numerous legs dangling from each side of its long body, the legs being more important than the body. Although the railroad now extends for 2,100 miles from Puerto Montt in the rainy south (41° S. Lat.) to Arica in the Atacama Desert (18° S. Lat.), there is no through traffic on this longitudinal route. The movement of passengers and freight between northern, middle, and southern Chile is handled predominantly by coastwise steamers. With the exception of the movement of produce from farm to city in Chile's well-populated central valley, there is little north-south railway traffic. Chile's great exports of copper, iron, nitrate, and much wool move west by short lines to the nearest port for shipment overseas.

Many Chilean ports have miserable harbors or none at all, yet the tonnage of cargo handled by these ports is remarkably large. Thus, 1½ million tons of sodium nitrate are exported from the Atacama Desert each year, chiefly through Antofagasta and Iquique, tramp ships handling about two-thirds of this trade. Approximately 1½ million tons of iron ore are shipped each year from the Bethlehem Steel Corporation's mines at El Tofo to its modern docks at Cruz Grande, where the ore is speedily loaded into the company's vessels and is carried via Panama to its steel plants at Sparrows Point, Md. The large copper shipments of Chuquicamata move to Antofagasta; Potrerillos copper, via Puerto Hundido; and that of El Teniente, through Valparaiso. From these ports liners carry about 500,000 tons of copper bars, ingots, and concentrates each year. In the north, Arica and Antofagasta are the coastal termini of international railway lines that carry the exports of tin, copper, silver, and other ores from landlocked Bolivia.

The Andean Railroads. North of the Tropic of Capricorn the conditions of the eastern side of the continent are again repeated, and the district of greatest population shifts from the plain near the coast, as in Chile and Argentina, to the plateau, as in Brazil and Venezuela. This Andean highland, the highest plateau outside of Asia, runs at an elevation of 8,000 to 14,000 feet through Bolivia, Peru, and Ecuador and sinks to the enclosed valleys of Colombia where the Cauca River basin east of Buenaventura has an elevation of 3,300 feet. The plateau is enclosed on the eastern and western sides by the Cordilleras of the Andes, which present a front that is very high, uniform, and difficult of ascent. Over this barrier the trade routes must pass. South of the equator there are numerous trails established by the Incas and followed by trains of llamas and mules since the Spanish conquest. Within the past sixty years several railroads have, by fearful effort,[3] been built

[3] The difficulties of Andean railroading are illustrated by the first trans-Andean line that was formally opened April 5, 1910.

"The tunnel is 12,000 feet above sea level, between Valparaiso and Buenos Aires. Heretofore winter travelers have been compelled to go round by the Strait of Magellan, a cold and stormy voyage of fourteen or fifteen days. The tunnel project after being twice abandoned was finally accomplished by an American syndicate organized by W. R. Grace & Co., of New York.

"On the Argentine side the railway tracks are brought up the mountains by a series of 'rack sections,' or zigzags, as far as the first tunnel, called El Navaro, which is 5,325 feet long. Then, by a steel viaduct, they cross a tremendous gorge to the second tunnel, which is 15,195 feet long.

"On the Chile side the mountains fall so rapidly that it was necessary to build a series of screw-shaped tunnels describing a corkscrew 27,840 feet long and dropping 2,762 feet in that distance. The aggregate length of the several tunnels is

to the plateau and have become the chief means of communication with the sea.

The port of Antofagasta, in northern Chile, is the ocean terminus of the longest of the plateau railways. A line between 700 and 800 miles long crosses the Desert of Atacama and climbs to the plateau of Bolivia, which it traverses in a northerly direction to Oruro and La Paz where it connects with the steamers on Lake Titicaca.

The shortest rail route to the Bolivian plateau is that of the Arica-La Paz railway, 281 miles long. This road has unusually steep grades, and for 22 miles a cog-rail system must be used. Already this route has diverted much traffic from the longer routes leading from the plateau to the ports of Antofagasta, Chile, and Mollendo, Peru.

Lake Titicaca was attained many years ago by the Peruvian line that connects the Pacific port of Mollendo with the lake port of Puno. The lake was already navigated by steamers before the railroad reached its shore, the steamers having been carried up in sections on mule back. The steamers cross the lake to the Bolivian town of Chililaya, which along with Oruro, for years the terminus of the Antofagasta line, was the base of caravan trade to La Paz and other plateau points. Sometimes as many as a thousand pack animals could be seen at one time loading goods for the mines and settlements across the plateau. The Peruvian railroad extends northward from the lake and to Cuzco, the ancient Inca capital, a little way down the slope toward the Amazon. This railroad and the one to Antofagasta carry a limited amount of freight that is destined for, or comes from, the eastern slopes of the Andes, but the chief dependence of the railways is upon the mineral and pastoral products of the highlands. Large plains (mostly arid) are covered here and there with salt and borax; at other places they have flocks and even native crops of barley and potatoes. The historic Potosí mountain of silver and tin has never been worked by scientific methods, yet the plateau is one of the important tin districts of the world. Copper, gold, and other minerals seem to be abundant and their exploitation has but begun. Tens of thousands of square miles of mountain pasture support the llama and alpaca, while the sheep of Bolivia outrank in number those of leading American sheep states.

Peru has another plateau railway extending from Callao past Lima to Huancayo. This railroad taps the important mining district of Cerro de Pasco on the high plateau. Some years ago Cerro de Pasco ores were being carried on mule back a distance of ninety miles to the smelters at Oroya. This railroad was built by an American in the days of Peruvian guano prosperity, at a cost of $200,000 per mile and with a loss of more than 7,500 lives, through the terrible Andes, which, like the Mollendo road to the southward, it crosses at an elevation greater than that of Pike's Peak or Mt. Blanc. This railroad reaches a maximum elevation of 15,680 feet above sea level without the use of a cog-rail, and there are 67 bridges, 65

eleven miles."—*Philadelphia Ledger,* April 6, 1910.

Note the gradient in those tunnels.

In the 1930's the road was out of use for many months, because an Andean avalanche fomented by a warm rain dammed the Argentine valley up which the railroad went. A temporary lake formed itself behind this snow dam, overtopped it, quickly cut it out, and then there was a flood as it rushed down a mountain valley.

By Ewing Galloway, N. Y.

Through freight by steam and local freight by llama, at a railroad junction in the Peruvian Andes. The animals are resting after having brought in loads of copper ore and silver ore to the railway station at Monococha. If you load the llama too heavily, he will lie down. You can beat him, beat him to death, but he will not get up. Peru is very short of agricultural land, has been so since pre-Columbian times. It is fortunate that a country so limited has the aid of this cousin of the camel that can pick its living from an unpromising mountainside.

tunnels, and 16 switchbacks along the line. Passenger trains move downhill one day and back uphill the next, and accidents are virtually unknown. Although the mineral resources of the plateau are great, this line does not earn a profit on its original cost.

The Peruvian coast, like that of north Chile, has several short lines. They serve the coast settlements and the cotton and sugar plantations in an arid plain where 1,000 square miles are irrigated with Andean snow water, and unfortunately but little more may be irrigated later. Peru does not promise agricultural expansion. Its westernmost point has an export of petroleum. All Peruvian ports import wheat, flour, butter and lard.

The Ecuadorean Railroad and Commerce. Still another Andean railway is in Ecuador. This country possesses a fertile and well-watered plain between the mountains and the Pacific. Here is the port of Guayaquil, the gateway to forests producing tagua nuts and cacao; but the truly equatorial climate causes the center of Ecuadorean population to be in the enclosed plateau about 40 by 300 miles lying between the ranges of the Andes containing the world-famous volcanoes Cotopaxi and Chimborazo. Here nearly a million people lived until near the end of the first decade of this century, entirely cut off from all communication with the commercial world, except by a pack trail descending from

the 10,000-foot plateau by perilous ledges and crossing swamps that often become impassable in the rainy season. A 350-mile railroad was at last constructed by American capital, from Guayaquil to Quito, the capital. It opened no new trade routes, but revolutionized the methods and commerce of an old one. It made possible, for the first time, the participation of these people in world commerce. This road practically annexed to the commercial world a new province containing a million people. Their commerce is likely to be of limited extent, because they live in the temperate zone climate of the high plateau where the country is so rough that there is small likelihood of their having any surplus of wheat, corn, or beans to send any farther than to their neighbor of the tropic plain, if perchance they can compete even there with temperate zone foods. Their exports are, therefore, likely to continue largely of hides and wool, and minerals of which the country claims considerable store. The imports comprise the whole list of manufactures and supplies needed in a modern city and in a surrounding farming district.

The Route to Western Colombia. The northernmost Andean trade route connects the Pacific port of Buenaventura, in Colombia, with the enclosed valley along the upper course of the Cauca River. This stream is a branch of the Magdalena and therefore drains into the Caribbean, but the mountains of central Colombia cut it off from the Atlantic by a high plateau and convert the valley into impassable narrow canyons with tumultuous waterfalls. A railroad now extends eastward from Buenaventura across a mountain range, about 6,000 feet high, to Cali, where it connects with a north-south line that runs through the upper Cauca Valley from Popayán as far north as Manizales. One branch of this valley line reaches eastward to Ibagué, where an automobile highway crosses the lofty Cordillera Central to Armenia, terminus of a railway line that extends to Bogotá. Colombia's two largest cities, Bogotá and Medellín, still lack rail contact with the sea. The Cauca Valley differs from all the other regions within the Andes and tributary to the Pacific in being low enough (3,000 to 3,500 feet) to be thoroughly tropical in its production and trade.

The Panama Canal and Its Effect on Trade Routes. Until the opening of the Panama Canal the heavy commerce of South America depended upon the route through the Strait of Magellan. Steamship lines from Europe and New York had regular services down the east coast, through the straits, and as far north as Peru or Ecuador. Now this is divided into two sets of lines, the easternmost of which stop at Buenos Aires and the westernmost of which stop at central Chile. These lines carry outward a general assortment of manufactures, machinery, clothing and the supplies for raw material producing countries. The return cargo on the western side consists predominantly of minerals and, to a limited extent, of sugar and cotton from Peru, cacao from Ecuador, and tobacco, hides, and miscellaneous agricultural products. The movement of Chilean nitrate remains a tramp trade, and occasional shipments of Peruvian cotton, sugar, hides, and ore are made by tramp, but nearly all other cargoes are now handled by vessels engaged in regular liner services connecting the Pa-

cific ports with northeastern United States and northwestern Europe.

The opening of the new outlet toward the north changed the direction of the commercial current, steamship lines by the score rearranged their itineraries, and tramp freighters by the hundreds and thousands, mostly nitrate ships, pass through the Canal in a steady procession. The west coast of South America is now as favorably placed for world trade as is the east coast. The land routes of western South America have their termini from 2,000 to 8,000 miles nearer the markets of the North Atlantic. This advantage gives a reduction in costs and a speedier delivery of goods that is stimulating the industries and extending the railroads and trade routes of the Pacific side of the continent.

The extension of railways and mining on the plateaus will intensify the present demand for the subtropical and tropical food supplies produced in the fertile valleys of the eastern slope, and desired on the plateau, a fairly populous region of temperate climate. Pack trains now supply La Paz and other plateau towns with lowland produce. Abundant water supplies will furnish electric power if it is required, many streams passing through 10,000 feet of descent in a short distance.

The communities of the eastern Andean slopes are chiefly occupied with feeding the miners of the plateau and receiving through it the factory products brought up by rail from the Pacific ports. From Bolivia to Colombia there are no transcontinental routes worthy of the name. A few auto roads so-called have been built, but for thousands of miles the continent is still utterly uncrossable except by the hardiest of exploring parties proceeding at some risk of life.

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The Trade and Routes of Africa and the Good Hope Route

1. The Commercial Development of the "Dark Continent"

The New African Commerce. Although Africa was circumnavigated before America was discovered, the sinister title of "Dark Continent" has stood into this very decade for the mysterious continent, devoid of commerce, but filled with the hidden dangers of the venomous unknown. African commerce has been thought of in terms of beads and savage barter, but now no continent is changing more rapidly. Old "Darkest Africa" is lightening fast. Its present commerce is relatively small, but a much more active future is promised as a result of the new transportation routes recently opened in all directions. The African transportation boom has been rivaled only by Soviet territory. African railroads and steamboat lines have been pushed much faster than commerce actually warrants, because colonial governments and the colonizing powers in Europe are building lines into the wilderness to subdue territory in the hope that commerce will come later. Trade trails are being cut through the thickest jungles, and immense areas have been opened for cultivation and colonization. The frontiers have been pushed back until but a comparatively small part of the continent is unreachable by white men.

Africa remained a closed continent until the end of the nineteenth century because the climate is usually bad for Europeans and because environmental conditions made the interior hard to reach. The regular coast line possesses very few good harbors. The continent generally is a plateau with abrupt descents toward the sea and a level interior, in some parts flooded during the rainy season. The great rivers, which in Europe, Asia, and America offer easy navigation far into the interior, in Africa come tumbling down toward tide level, blocking the navigation. These falls may make wondrous power some day, but for the past they have kept the continent closed. In the tropic sections the coasts are usually low, swampy, malarial, and unwholesome, almost prohibiting land transit to the interior and giving to the explorer and newcomer a most unfavorable idea of the entire continent. Only at the extreme ends of the continent have we had a coast along which human beings could prosper and white men live in any approach to comfort. Fortunately there also was the Nile, the one river which, despite its ten cataracts, has erstwhile been of some service to navigation and has in its valley sheltered

one of the oldest and most historic civilizations.

The Commercial Zones of Africa. The continent is further divided along east and west lines into five distinct economic zones, within each one of which the similar economic conditions of the people have not permitted extensive exchange, and between which the natural barriers to travel and transit have been almost prohibitive of any kind of communication, except that carried on by the exploring expedition. The best of these five regions, the temperate extremities of Africa with the Mediterranean climate—Barbary states and the Cape region—have not offered a favorable base for African development because they have a semi-arid climate and are cut off from the extensive and torrid interior by the two desert regions, the Kalahari Desert in the south and the vast stretches of the Sahara in the north. Despite the blistering blank of the deserts that have cut off the temperate and sub-tropic ends from the tropic middle there has been a limited trade across the wastes to the very large region comprising tropic Africa. In its eastern reaches the arid part of South Africa has more rain than Sahara, and east of the mountains the trade winds give good rainfall to Natal for there is here no moisture-blocking land mass like Arabia, which cuts off the possibility of rain from the corresponding north latitude land.

The Transportation Methods of the Old Africa. Three distinct methods of transportation have prevailed in the different parts of Africa. Wagon trains drawn by oxen have carried trading expeditions from the Cape to the Zambezi River; and the well-known caravans of the Sahara have kept up a feeble trade between Morocco and the Mediterranean ports on the one hand and Timbuktu, Lake Chad and other Sudan points on the other. The interesting and picturesque "ship of the desert," the camel, and the camel caravan, have been much emphasized in the education of the youth of Western civilization, and it is therefore easy to overemphasize their importance in world commerce. Statistics of the Sahara caravan trade, which sets out from Algiers, Tunis, and Tripoli, indicate that it amounts in the twentieth century to but little over half a million dollars annually.

Central Africa has the third and least efficient means of transportation. Between the Sudan and the Zambezi the meager commerce, until recently in the hands of Arabs and Negroes, has been borne in canoes or by caravans of men, because the climate was fatal to beasts of burden. Some ivory, rubber, skins, palm nuts, and other products of high value were carried to the coast by these laborious means, and bartered for European goods brought by the vessels that traded along the coast.

The Partition of Africa and the Reconstruction of the Routes. Excepting Egypt, Barbary, and the Cape, all of which are in the sub-tropical extremities, the commerce of Africa was too small, its prospects too unfavorable, to tempt the colonizing powers of Europe till late in the nineteenth century. Then came the scramble for African possessions; as nations began to stake off their homesteads, others rushed in before it became too late. The whole central region of darkness was quickly divided, and a new era in African commerce began.

The European powers have annexed,

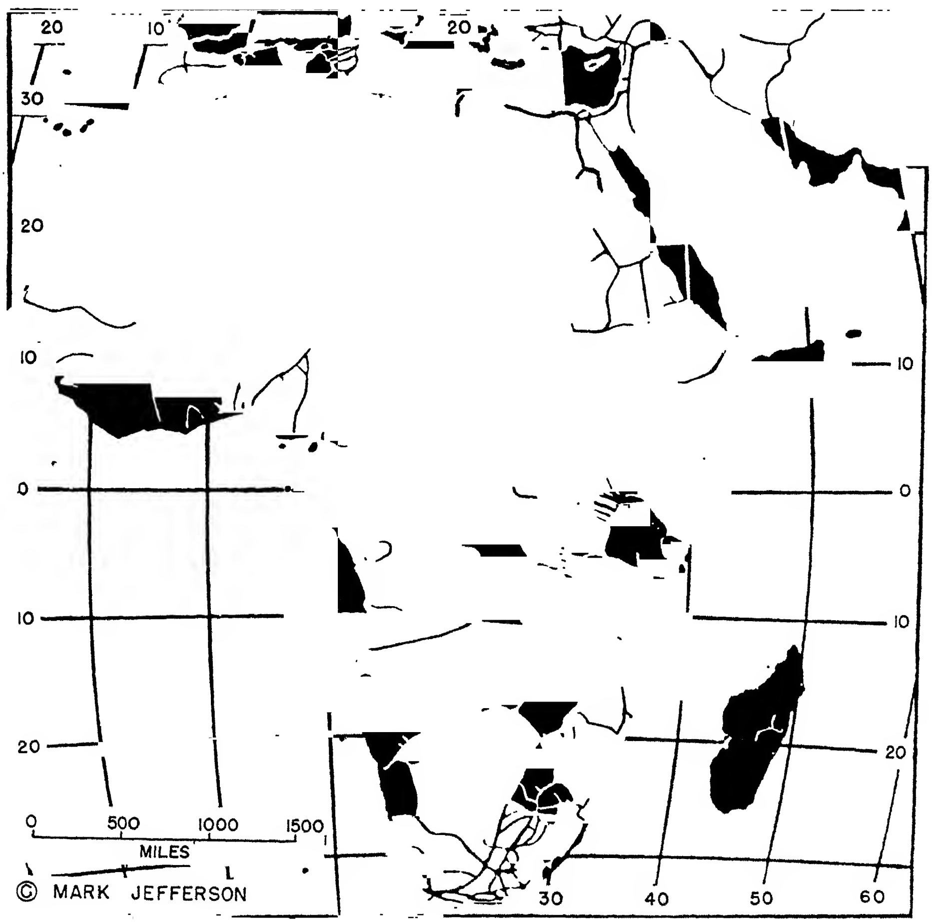
divided and traded land, and reconstructed the map. Now the European pioneers, explorers, capitalists, and colonizing governments have busied themselves and the native worker by laying out railroads and steamship lines to replace the feeble means otherwise provided.

Naturally the easiest way to begin was to send good steamers to the coast. The ocean must ever be the great thoroughfare of African trade. No other continent promises to be so absolutely dependent upon ocean commerce, for Africa has less prospect than any other continent of developing manufacturing and agriculture that will supply her own needs, and therefore will have greater dependence upon other continents whose products she can get only by trade across the sea which skirts her even coasts. The coasting steamers of Great Britain and other European countries have already well attended to Africa's ocean routes.

Scores of African coast ports are now regularly visited by European steamers, and the continent is regularly circumnavigated in both directions. From this base the attack upon the land has begun. From important ports railroads have been built inland to tap the navigable lakes and rivers, and pierce the very heart of the continent with the steam-driven freight carriers of civilization.

African Railroads. Among all continents, Africa has least access to the railroad, a fact that is clearly shown by the large black areas on Mark Jefferson's map (see Fig. 888). Nowhere in Africa is there even the beginning of a dense railweb comparable to the one that now serves the productive Argentine pampa. In its northern and southern extremities the African continent is drier, more temperate, and more progressive than the rest, and here transportation facilities are best. The Union of South Africa is reasonably well served with an extensive railnet, and smaller nets have been developed in the Barbary states and in Egypt. With the exception of the Egyptian Nile, navigable rivers do not exist in the northern and southern parts of the continent. In Egypt the railroad and the motor truck have taken most of the freight traffic from the majestic Nile. Throughout North Africa the picturesque camel caravan has lost much of its trade to the railroad and the ubiquitous motor truck. Indeed, not even the burning sands of Sahara can halt the rugged, four-wheeled wonders from Detroit. Likewise, South Africa has seen a revolution in transportation, and its ox-cart caravans that once carried men and goods from the Zambezi to the Cape are now relics of the past. Now they only carry some freight to the railway station.

Most of Africa is a colonial appendage of Europe, and the role of Britain's empire builders is shown by the fact that two-thirds of the continent's railway mileage is concentrated in the Union of South Africa and British colonies and mandates. One of these builders of empire was Cecil Rhodes, who during the latter part of the last century dreamed of a line spanning the continent from the Cape of Good Hope to Cairo, Egypt. Approximately three-fourths of this ambitious transcontinental rail route has been completed. It is now possible to travel by rail northward from Capetown to Lake Tanganyika and southward from Cairo through Khartoum to



In looking at this map, one should not forget the Niger, the Congo and their branches. Navigable rivers are not shown on this map. The small, disconnected railroads in Central Africa are really portage routes or feeders for the Congo boat system.

No further development is likely to put a railroad across the dry heart of Africa, namely, the Sahara or Great Desert. The lands north of it are of course adjacent to the Mediterranean, and those south of it are nearer to the Atlantic than to the Mediterranean, and there is no economic reason for a railroad to cross its shimmering wastes.

Kosti on the White Nile, but the intermediate section involves the use of lake and river boats, a few short railroads, and the pack animal or automobile. If the Cape-to-Cairo Railroad is ever completed, it may have some military importance, but through commercial traffic will be virtually nil. This overland route is paralleled by the open sea, which affords much cheaper transportation. Africa does not need such a transcontinental railroad, for unlike the great Trans-Siberian Railroad, the Cape-to-Cairo route does not tap a rich, landlocked, remote continental interior. In the future most commodities will move, as they do now, along the southern and northern extremities of the route and

By Burton Holmes, from Ewing Galloway

This multiple span ox team in the mountains of Cape Colony shows the transport system that prevailed over most of South Africa for most of the time since its early settlement and still persists in some localities. This is a short team in comparison to some.

along its eastern connections to the nearest seaport.

The flow of African railway freight is distinctly centrifugal. Local traffic is small, and the outflow of minerals, crops, and pastoral and forest products far exceeds the volume of inbound manufactures from foreign lands. The prime function of African railroads is shown by the outbound shipments of phosphate from French North Africa, cotton from Uganda, Nigeria, and Anglo-Egyptian Sudan, coal from Natal, palm kernels from Southwest Africa, cacao from West Africa, and copper and other minerals from Northern Rhodesia and the Belgian Congo.

African Rivers and Lakes. Most African rivers are interrupted by numerous rapids and waterfalls and come tumbling down over escarpments as they near the sea. In the past, long lines of native porters have carried all freight around these rapids and waterfalls, each porter bearing a load of 50 to 120 pounds, but on the major river routes of today these caravans of porters have been replaced by little river-link or portage railroads.

Most of central Africa from about 17° N. to about 17° S. remains dependent upon rivers and lakes for much of its transportation. Long water-and-rail routes lead down from the continental

interior to various seaports, for as yet only the rich copper mines of the Belgian Congo and Northern Rhodesia and the tin mines and cotton fields of upper Nigeria have long and continuous rail routes to the sea. Lakes Nyasa, Tanganyika, Victoria, Rudolph, and Chad are no longer names of mystery, for these lakes, like the Congo and Niger rivers, have regular steamship services today. Canoes and caravans of porters are still used for the carriage of freight beyond the steamer's track and the railway line, but the advent of the truck has greatly facilitated commerce in many parts of "Darkest Africa."

The Nile River Route. In spite of its cataracts, the Nile River for centuries was the main thoroughfare connecting the Mediterranean world with equatorial Africa. In the days of sail, river craft proceeded upstream with the aid of the prevailing north and northeast winds, and on the return voyage the sails were lowered, the vessels drifting slowly downstream. Like many another river, the Nile has lost most of its freight traffic to the railroad, which now parallels its lower course from Alexandria to the First Cataract, just below the great Aswàn Dam. Most of Egypt's exports of phosphate rock, rice, onions, and refined sugar move down to the sea by rail. Between the First and Second Cataracts there is no railroad, and the river competes only with the motor truck and the camel caravan. Above the Second Cataract a railroad extends far into the Sudan to Sennãr on the Blue Nile and southwest to Kosti on the White Nile. This line is a great carrier of freight, for it is linked by a branch with Port Sudan on the Red Sea which is the outlet for the large exports of short-staple cotton from the Anglo-Egyptian Sudan. Today the Nile stands unique among the world's great rivers in that more than 80% of its traffic is passenger trade.[1] Most of the passengers are opulent American and European tourists gaping at the pyramids and desert scenery from the decks of luxurious steamers, which are operated by the well-known firm of Thos. Cook & Sons.

Rail Routes of South and East Africa. The South African lines are making greater industrial changes than are the Egyptian railways. Egypt has always had its Nile, but South Africa had only its veldt and its oxen. The railroads which are so necessary are going in many directions to develop a constantly enlarging frontier. Cape Colony, Natal, the Transvaal, and Orange River Colony are a pastoral and mining region, resembling some parts of the western United States and having an area a little larger than Texas and New Mexico. In this region the white man, with his ranch, is crowding out the pastoral native and doing some dry farming. Indeed, surprising amounts of wheat and even corn are grown, and there is an expanding railway net. The backbone of this railway system, the trunk line running north from Capetown, has been pushed steadily northward. In 1910 it was far beyond the Zambezi and more than half way from the tropic to the equator. At the present time it reaches the Belgian Congo town of Elizabethville, where it connects with rail and water-and-rail routes extending westward and northwestward to the Atlan-

[1] See Alfred C. Hardy, *World Shipping*, Penguin Books, Ltd., London, 1943, pp. 122-123.

tic. It has five major side lines to the east coast, terminating at Port Elizabeth, East London, Durban, Lourenço Marques, and Beira.

These side roads carry down to the sea the wool, hides, and mohair of the ranchmen on the arid plains and the gold, diamonds, and copper from some of the world's greatest mines. In exchange comes a great variety of European and American manufactures needed in the mine, farm, repair shop, and home. As is the case with most such regions the leading classes of imports are iron and steel (including machinery), clothing, and food. Greatest of all east coast ports is Durban, where many a tramp steamer picks up a cargo of coal for one of the widely scattered ports of the Indian Ocean area. There is surprisingly little freight passing from Capetown to Johannesburg and Pretoria. These cities receive most of their imports through the side railroads from Delagoa Bay (Lourenço Marques) and Durban, a tendency which will leave the Cape-to-Cairo line of the future no more through trade than exists on the line from Bordeaux to Odessa.

The port of Dar-es-Salaam in Tanganyika Territory is served by a railroad that extends inland to Ujiji on Lake Tanganyika and which has a branch line running northward from Tabora to Lake Victoria. Steamer service is maintained between Ujiji and Albertville on the western shore of Lake Tanganyika which, in turn, is linked by rail with Kabalo on the Lualaba-Congo River. Farther north a railroad extends inland from the port of Mombasa in Kenya Colony to Entebbe, capital of Uganda on the north shore of Lake Victoria. By these routes the cotton and other products of Tanganyika, Uganda, and Kenya move down to the coast for shipment overseas.

Large areas in this East African region, now coming into the European commercial zone, are high, with a climate dry enough and cool enough to be free from many tropic disadvantages, and Europeans have colonized here in the hope of producing cattle, cotton, and other agricultural produce in large quantities. The plateau near the Uganda railroad is 5,450 feet high at Nairobi, and European ranchers have taken up more than a million acres of land to the shame of the white man. In equatorial Africa cattle thrive only in highland areas, which are free of the tsetse fly.

West African Routes. West Africa shows an amount of railroad building that is likely to be surprising to anyone who has not followed it closely.[2]

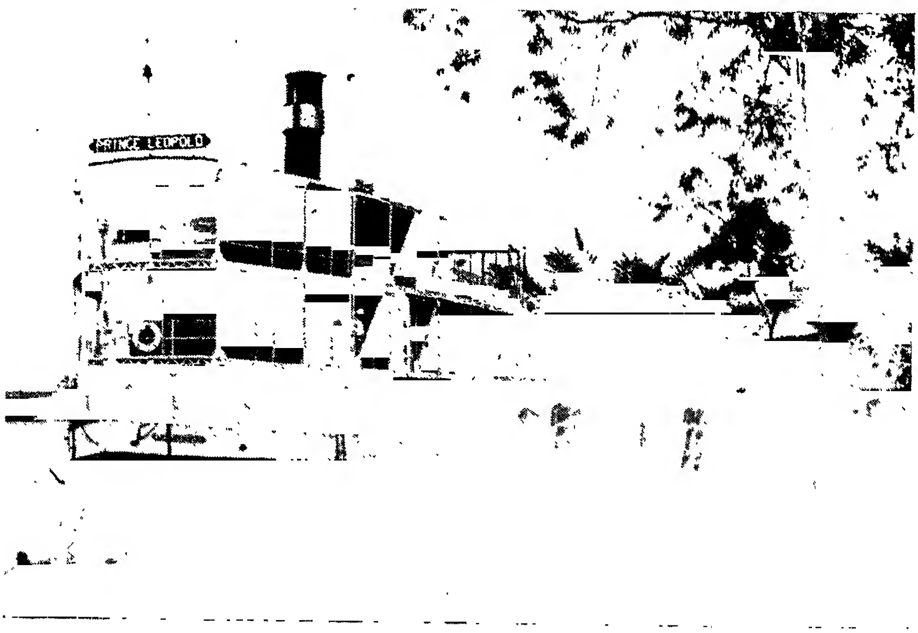
In Southwest Africa (formerly German) the railroad runs from Walvis Bay near the Tropic of Capricorn to Windhoek, 237 miles from the coast,

[2] There is a mighty difference between the seriousness with which we can take the projection of railways in Tropic America and Tropic Africa. Many of the American governments are poor, weak, corrupt, and properly almost devoid of credit. They cannot build roads or operate them; private enterprise must therefore build them for profit and then endure the disturbances of civil wars. The African colony represents the firm hand of Europe and abundant credit. The European government backs up its colony; the colonial council, dominated by Europeans, uses the colonial credit and revenues to build and operate a railroad at a loss or no profit in the hope of building up the colony. Thus the British East African Protectorate spent over $30,000,000 in building the Uganda railway from Mombasa to Lake Victoria, without expectation of any income from it for many years. In Latin America a ruling dictator will grant concessions (franchises) for railway building, and the concessionaries try to tempt private capitalists to build the line. Meanwhile the railroad is "projected."

and winds southward into the Orange River country where it connects with the South African railway system. One branch of this line extends westward to the little port of Luderitz. At present the traffic is light in this African Nevada.

In Portuguese Angola the Benguela Railroad was completed in 1931, this 1,300 mile line providing the Katanga copper district with its only all-rail route to the Atlantic (see Fig. 888). The Benguela Railroad is shorter than the railway line leading to the Indian Ocean port of Beira and cuts about 3,000 miles off the trip to Europe. Most of the traffic of Katanga has moved via the Benguela route since its completion. From Loanda and Mossámedes on the Angolan coast railroads are being pushed eastward, but their traffic is small.

The Congo River Route. The Congo River is the longest and greatest of central African waterways, the river and its tributaries providing about 6,300 miles of navigable water. Ocean vessels call at Matadi, 83 miles from the river's mouth, and a 250-mile railroad connects with steamers at Leopoldville, on Stanley Pool, above the numerous falls. The commercial changes of the new Africa can be easily inferred from the effects of the railroad from Matadi to Leopoldville. The journey used to require 20 days, with considerable loss of life. The freight rate was about $10 per load when carried by human porters, or about $250 per ton. The journey now takes 2 days,



By Ewing Galloway, N. Y.

The steamer, *Prince Leopold,* on the Lualaba (above Stanley Falls on the upper Congo River), Belgian Congo. This boat, brought in pieces from Europe, is one of two that maintain regular fortnightly service on the Lualaba. The top deck is the home of the Belgian captain and his family. The middle deck is for the white passengers. The lower deck is for the natives and such animals as may be transported.

Kano, over 700 miles by rail from Lagos, is the commercial metropolis of northern Nigeria and the terminus for the caravans which come from the Sahara and from the Sudanese Steppe, a land of good goat skins. The Sudan is one of the most populous and promising parts of tropic Africa. Geographers report cities of 60,000 to 100,000 people, who are, for Africa, industrious; and the climate and the country are suited to livestock. A transition region (grassland) between the desert to the north and the jungle to the south, it is proving to be good for cotton growing. It is Africa's land of promise, with a potential cotton area in Nigeria alone five-sixths as large as that of the United States, and the British Government is not neglecting it.

West of Nigeria is the French colony of Dahomey with the port of Kotonu, which has 431 miles of railroad going northward into the interior. Next comes Togoland where the port of Lome has 261 miles of railroad tapping its hinterland. West of Togoland is the British Gold Coast colony, which under the leadership of white men mainly from Great Britain, has developed a valuable tree crop agriculture. From less than 6,000 tons in 1905, the output of the cacao plantations has risen to 263,000 tons in 1938, with an export value of $23,000,000. The Gold Coast now produces from one-third to one-half of the world's cacao crop. This cacao is grown by native patch farmers. The principal Gold Coast ports of Sekondi and Akkra are the bases for 490 miles of railroad. About 20 miles west of Sekondi the British have built an artificial harbor at Takoradi, the only good harbor on 1,200 miles of coastline between Liberia and Nigeria.[5]

Between the Gold Coast and Liberia is the French colony of Ivory Coast, where an energetic French administration has constructed 501 miles of railway and plans to continue the line north to the Niger River. Liberia, with no ambitious Europeans to urge improvements, has no railroads, and its 200 miles of highway were only recently built. The Firestone rubber plantations are certain to be an interesting experiment. West of Liberia is British Sierra Leone with an excellent natural harbor, 36 feet deep and a coaling station at Freetown, the most important seaport in West Africa. The railway mileage of Sierra Leone totals about 311 miles.

The rapidly growing export of the whole Guinea coast, a century ago known all over the world as a seller of slaves, consists primarily of palm oil, palm kernels, cacao, peanuts and other oilseeds, mahogany, a little rubber and other gums, and a significant beginning of cotton and tin. The imports are chiefly cotton goods and the varied list of modern manufactures now desired even in lands where living is primitive.

The West African Route to Timbuktu. Alas for the myths of geography, Timbuktu, with its jingling rimes, typical of remoteness, has become a commercial reality of steam and rail and telegraph, not to mention radio, and its safe steam route to the sea has sadly cut into the traffic of the tedious caravans that had for ages wended their way from one oasis full of robbers to another on the long journey to the Mediter-

[5] See George F. Deasy, "The Harbors of Africa," *Econ. Geog.*, vol. 18, October, 1942, pp. 325-342.

ranean coast. To reach the region of Timbuktu in the French Sudan, three far-reaching trade routes have been established from French West Africa. The chief port is Dakar with five lines of European steamers calling. From Dakar a railroad 165 miles in length connects with Saint Louis at the mouth of the Senegal River, a stream which has been much improved for navigation so that steamers now ascend in the rainy season to Kayes, 570 miles. Kayes in turn is the western end of a 344-mile railroad to the navigable upper Niger, on which steamers run to a point 150 miles below Timbuktu, where the river becomes choked with flying sand from Sahara. This route by way of Saint Louis and the Senegal River has been partially superseded by a railway running direct from Dakar to Kayes and hence by the older route to Bamako and Koulikoro on the upper Niger. Still a third railway 386 miles in length runs from the port of Konakry in French Guinea to Kourousa on the upper Niger and to Kankan 46 miles further. This area has what seems to be an almost unique possibility of greatly increased wealth. The atlases show that, between latitude 13° and 18° N., in the French Sudan, the Niger, flowing northward, bifurcates, develops distributaries, and wanders in swamps before getting itself together and becoming one river again. Professor Forbes of Tucson, Ariz., employed as an expert by the French, reports that the river has abandoned one area, leaving large areas of alluvial deposits that were built out into a lake now abandoned and dry. This is greatly like the Imperial Valley of California and Mexico. Dr. Forbes thinks it is an area of great promise if handled in the necessary big engineering way—a little Egypt, and not so little either.

The trade of Senegal differs from that of the other colonies to the east of it in that peanuts comprise the bulk of the export.

The Barbary States. The trade routes of North Africa are simple. The Mediterranean Sea serves as the highway in the first instance for most of this region of the desert's edge. In Algeria, the largest and the richest of the colonies of France, and in Tunis there are good systems of railway running out from the ports of Oran, Algiers and Tunis,[6] where many steamers call and whence direct lines go to Marseilles, which is one of the great markets for the wheat, wine, olives, wool, and early vegetables from the north of Africa. The French colonies of Tunisia, Algeria, and Morocco together have about 6,000 miles of railway lines, as compared with 16,000 miles in South Africa and 4,700 miles in Egypt and the Anglo-Egyptian Sudan. Several railroads, largely military in their purpose of construction, have been built across the Atlas Mountains and into the edge of the Sahara in both Algeria and Tunisia. This is stimulating the date trade from the oases which had before depended upon the camel. There is a little trade across the desert, employing about 30,000 camels, but it is insignificant for two reasons: the great danger of robbers and the increasing ease of reaching the Sudan from the south. Morocco has several lines of rail-

[6] The whole of this region is very promising as a field for future mineral development, excepting coal. For instance, railroads in southwestern Tunis bring to the port of Sfax hundreds of thousands of tons of phosphate rock from deposits of vast extent. Bedouins who want some money often come here and work for a while.

By Ewing Galloway, N. Y.

The Sahara, or Great Desert. South of Algiers, where this picture was taken, and in other parts of the Sahara, there are hundreds of miles of such billowy waste, through which the Arab, with his one-humped camel, has been threading his perilous way for many centuries.

road running inward from Mogador, Casablanca, Rabat, and Tangier to inland places such as Fez. Where the rail route stops the caravan route begins.

Minor Lines of Transport. Africa has of course many minor trade routes and some railroads that do not merit consideration among the leading routes. For example, there is a very long list of little stopping places on the west coast of Africa where the European steamers get the mahogany, rubber, palm nuts, and ivory which the natives assemble by any and all means in their power.

At several points on the east and west coasts are short lines of railway reaching inland from coast ports. Some of them may become routes of importance. One of the more promising ones runs 485 miles from the port of Jibuti in French Somaliland opposite Aden to Addis Ababa, 8,000 feet high on the Ethiopian plateau. Lying wholly in the tropics, its capital in the same latitude as Panama and its southern border barely three degrees from the equator, the greater part of Ethiopia has a temperate zone climate, and it can grow many of the temperate zone crops. Thus it has the basis for a future trade with the tropic regions so close at hand.

In conclusion the two main facts should be kept in view—that the main problem for African trade is in every case the establishment of rail outlets to the sea; and, second, that the interior has important waterways which it has been the first problem of the railroad builders to tap and develop. For the commercial development of natural resources and modern transportation, most of Africa remains dependent upon the initiative and capital funds of the peoples of northwestern Europe.

The African trade, like that of South America, is served in different sections by different sets of steamship lines. This is very properly so, not only because of distance, but because of the different

commercial requirements of equatorial primitives in breech cloth and imperial British in broadcloth at Capetown.

South African Connections. The first trade region in point of age and present importance is that of British South Africa, served by several lines of splendid steamers working in unison and giving service from the leading ports of northwestern Europe and from the Atlantic and Gulf ports of the United States. The liners engaged in the South African trade usually pay no heed whatever to all the rest of Africa, but steam directly from Europe and America to Capetown and skirt the coast to Lourenço Marques, stopping at Port Elizabeth, East London, and Durban. Liner companies are firmly intrenched in the South African trade. Coal from Durban for Indian Ocean ports is the tramp's great cargo, and only occasionally do tramps carry full cargoes of hides, corn, sugar, wattle bark, and ore to northwestern Europe.

Tropic West Africa. The trade of tropic West Africa is served by a number of lines of steamers that skirt the coast from the Sahara to the Kalahari Desert. The number of ports visited varies, some of the lines going all the way to Walvis Bay and others attending to the needs of various smaller sections of the coast. These steamship lines make of Liverpool, London, Hamburg, Antwerp, Le Havre, and Marseilles the great depots of West African trade. Liverpool specializes in mahogany logs and divides the rubber with London and Hamburg, Antwerp gets the ivory, and Marseilles is the leader in palm oil and peanuts. New York now has 4 direct liner services to the African west coast. The huge cacao trade of the Gold Coast, Nigeria, and the islands of Principe, São Thome, and Fernando Po is handled entirely by liners, but tramps obtain many cargoes of palm kernels, peanuts, cotton, hardwoods, and ores.

East Africa. Some of the trade of the East African coast is served by several lines of European steamers—British, French, Italian, and German (before 1939)—that come through the Mediterranean. A line of smaller steamers connects with dozens of steamers a month at Aden, and runs up and down the coast to Zanzibar, an important trading center and the capital of an island producing the bulk of the world's cloves. A steamship line runs from Zanzibar to Bombay and practically all of the commerce of the coast is carried on by a few thousand East Indians. Like West Africa, the chief imports of East Africa are textiles, metals, foods, and liquors, and the exports are hides, rubber, copra, spices, and, most recent of all, the copper of Katanga and the cotton of Uganda, Tanganyika, Mozambique, and Kenya.

2. *The Good Hope Route*

Separated from, yet attached to, the trade of Africa is the Good Hope route. This is the oldest of the great ocean trade routes. It is practically co-eval with the history of America, and the commercial history of this contested route is told in the colonies and peoples that are now to be found in South Africa. The Portuguese discovered and for a time monopolized the route, and their decayed colonies still exist to the north and west of the Dutch settlements. When the Dutch had triumphed over Portugal, they rejoiced in the monopoly

of the commerce of the Far East. In the seventeenth century this trade was carried on almost exclusively by the way of the Cape of Good Hope, where the Dutch made settlements that served as a half-way post and victualing station for the inefficient sailing ships bound on the long and tedious voyage to the Indies. Then followed a century of commercial and naval struggle between Holland, France, and England, with the triumph of England. Her ships became the predominant ones rounding the Cape. She won and yet controls the colonies which had their start as the Portuguese and Dutch half-way posts on the route to India, and her people drove the Dutch inland as the Portuguese had been driven up the coasts both east and west. The Dutch (Boers) held inland areas of no value to sea people until gold and diamonds appeared. That began greatly to interest the capitalistic British. The Boer war followed and now this territory is all red on the political map.

The Good Hope route is really a group of routes rather than a single route and actually narrows to a single track at no place in its prodigious length save where it rounds the Cape. It is at least threefold beyond that point; and, like the Mediterranean-Asiatic, it has double termini from the eastern and western shores of the North Atlantic—the English Channel and the New York Bay. Beyond the point of Africa one branch turns to the north and follows the east coast of Africa, another goes to the East Indies, and a third directly to the south shore of Australia (see Fig. 831).

The steamer tracks in the Atlantic go so nearly north and south that there is little great circle curvature noticeable; but the great circle route from the Cape to Wellington, New Zealand, cuts off 750 miles from the distance between the same ports via Melbourne. Unfortunately, the great circle reaches a latitude of so much ice and bad weather that it is not much used as a route in winter.

Sailing Vessel Tracks. The Good Hope route passes over a part of the world containing great expanses of ocean and comparative barrenness of land, giving sea voyages of great length between the isolated land areas. In this respect it differs radically from the Mediterranean-Asiatic route. The great distances from the Cape of Good Hope to Europe or America, or to any other lands, have combined with the favorable winds of the Atlantic and Indian oceans to make this route the last great stronghold of the sailing vessel. Indeed, a few years ago it was declared that this was a stronghold from which steam could never displace sail.

This prediction has, however, been disproved by the great improvement of the steamer and its adoption within the past forty years for the trade of every important division of the globe, including the various subdivisions of the Good Hope route. Prior to World War I, as much as 40% of Australian wheat exports were carried in sailing vessels,[7] but the sailing tramp has finally disappeared from this trade.

The peculiar location and windings of the sailing tracks are explained in terms of the prevailing winds. For the sailing captain the quickest way is the shortest, regardless of actual distance;

[7] A statement by one of the largest wheat exporters in Australia.—Letter of August 22, 1935, to the junior author from Mr. Albert M. Doyle, American Consul, Sydney, Australia.

for the steamer captain the shortest way is usually the quickest. Or, putting it in another way, the steam navigator being practically independent of wind and current, thinks in miles, follows a great circle, and along shore he goes from point to point and headland to headland in nearly straight lines. The sailing captain thinks in days. If the vessel makes 30 miles a day by the direct route and 100 miles a day by the circuitous route where the winds are good, he makes a great detour and saves time. The peculiarities of wind and current often make detours advisable. In fact, it is almost invariably true that the steam route and the sail route between two points differ in location, and if they do happen to agree one way they are apt to differ on the return, for it is uncommon for the sailing vessel to go and return over the same track. All of these sailing peculiarities are admirably illustrated on the Good Hope route with its double sets of crooked sailing tracks. To understand them one must know the main facts of the wind systems.

In the Atlantic north of 25° or 30° North Latitude, depending on the season, the wind, except when disturbed by cyclonic storms, is normally from the west at all seasons, and from the southern edge of these westerlies down to the vicinity of the equator the trade winds blow almost uniformly from the northeast. South of the equator the trade winds are duplicated, but blowing this time from the southeast. Near the latitude of Good Hope the prevailing westerlies are again reached. They blow here with great force ("roaring forties") and sweep unimpeded around the world.

The trade winds blowing from Spain toward Brazil make it necessary for a vessel from New York to go nearly across the Atlantic with the westerly wind before turning into the trades in company with the European contingent, which has had a very direct sail. The southeast trades can be crossed at best advantage by taking a right-angle course, close to the coast of Brazil, and proceeding southward into the prevailing westerlies before which the vessel rides as far as possible before turning northward to her destination. A glance at the map shows that the combined result of the northern and southern westerly winds is to give the track from New York to Good Hope the shape of a rough letter S reversed.

Sailing vessels rounding Good Hope from the east hugged the coast as closely as possible to avoid the west winds, and if bound for New York they had a direct course going with one trade wind and at right angles to the other.

The Indian Ocean has a different wind system, with a peculiarity in it. In the winter it is like that of the Atlantic, minus a northern zone of westerly winds. In the summer the northern (northeast) trade wind is reversed, and blows toward Asia as a strong southwest wind called the monsoon. These winds make it necessary for the winter vessel from Good Hope to Bombay to creep around by Ceylon to get in a position to cross the northeast trade wind at a right angle by going up the coast of Hindustan. When the summer monsoon begins, the out-going vessel from Bombay must take the same track as the in-coming vessel in winter, for in no other way can she utilize the southwest monsoon which sets squarely toward the coast.

The coal supply upon this route was unsatisfactory, both in the supply along the route and the conditions for transporting it thither, until after Natal began to supply good steaming coal at Durban. This former lack of coal was another factor helping to explain the late survival of the sailing vessel preeminence there. Vessels starting from Great Britain or the United States did not approach another coal-producing country until Australia was reached, full half way round the world from the starting-point.

Traffic. The maps clearly show that this is a long route for any of the Asiatic traffic. The opening of the Suez Canal, with its short-cut connection, was a great blow to the traffic of the Good Hope route, which, before that time, had almost had a four-century monopoly of the trade between Asia and the West. The growth of the Suez traffic cut into the Good Hope traffic, but the great expansion of commerce during the past fifty years has caused a rejuvenation of the commerce which passed to and around the Cape. Australia and Africa have risen from the ranks of outposts of civilization to states producing and consuming freight by the millions of tons.

The traffic of South Africa is a very peculiar one in the world's trade. Regions of sparse population and comparatively recent settlement are usually producers of large quantities of raw material and consumers of manufactures, which comprise a much smaller tonnage. Such has been the commercial history of practically every country in the New World; but, owing to the scanty rainfall, which precludes extensive agriculture in most of South Africa, and the great predominance of gold and diamond mining among the industries there, South Africa imports lumber, wheat, flour, machinery, and general manufactures, and pays for them in such commodities as gold, copper, diamonds, ostrich feathers, wool, mohair, hides and skins, corn, cane sugar, and meat. The old saying that "good goods come in small packages" here holds true, so that a vessel carrying a cargo to South Africa often faces the prospect of going away practically empty. The Cape is therefore a scattering point for vessels in ballast seeking freight. Some go west to South America; others pass to Bombay for grain and cotton; to Rangoon for rice; to Java for sugar; or to Calcutta for jute.

The largest traffic movement that passes the Cape is the trade of Australia. Despite the existence of the Suez Canal and the splendid German and British steamer lines which reach Australia by that route, the bulk of Australian commerce follows the cheaper open-sea route around Africa, which is after all but 1,000 miles longer. Only the mail, passenger, and a limited freight traffic are taken by the lines on the shorter but more expensive Suez route. The tramps and cargo liners, of which there are many, find it more profitable to follow the ancient way discovered by da Gama than the new one dug by de Lesseps.

Upon the whole, the traffic and the consequent vessel movement upon the Good Hope route are peculiarly one-sided. Much (in tons) goes out and less returns, and at every turn tramps leave this route and go seeking cargo to return to the North Atlantic by some other route.

The traffic of the Good Hope route has limitations upon its future. There are not at the present time 20 million people in South Africa and Australia combined. Owing to the limited agricultural resources of these British dominions, the population shows no promise of growing rapidly. That of Australia is almost static. Any trade to east Asia cannot be expected to pass around Africa since the passing of the sailing vessel. The trade of the Good Hope route is therefore largely limited to such part of the Australian and African traffic as will continue to use it in preference to some other route, as Panama and Suez. This trade from the regions now containing 20 millions must naturally be vastly less than that of the Mediterranean-Asiatic route, which has upon its lines a population sixty times as numerous but with far fewer commercial wants per capita than the inhabitants of the British possessions in the southern hemisphere. These people are, and will continue to be, among the heaviest per capita traders, while the Asiatic peoples are and will long be among the lightest.

The future of the American trade with South Africa and Australasia is particularly bright, because these British dominions are in the same stage of industrial development as parts of the American West. We have had experience with their kind of physical problems, our agricultural machinery is adapted to their kind of land, as our mining machinery is adapted to their mines, our automobiles to their roads. There is every reason to expect a continued and increasing trade in American machinery and supplies for the development of these new lands, while our mills and tanneries are increasingly dependent upon their wool, hides, skins, and tanning material.

The fact that South Africa has not been equipped by nature to start off as a great grain grower by extensive agriculture does not prevent her from having room for considerable areas under irrigation and possibly for grain growing without irrigation if improved varieties of grain are used. The same developments can probably extend Australia's production.

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The Trade and Routes of Australasia and the South Pacific

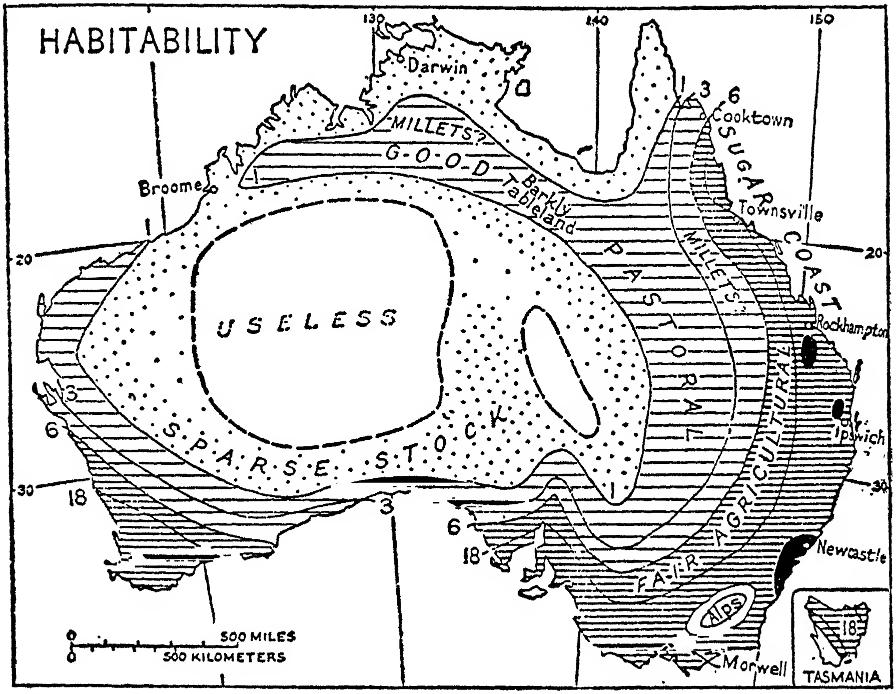
1: *Commercial Development of Australia and New Zealand*

A Watery Desert. The South Pacific and Indian oceans are a realm of waters, almost a world of waters, a saline, watery desert in which Australia and New Zealand are but little more than oases, and one of them, Australia, is largely desert. Compared to this wet desert the world's dry deserts are but insignificant scraps. The Pacific is classed as one of the oceans, but it is almost as large as all the rest of them combined. It is more than twice as large as the Atlantic and has an area estimated at 70 million square miles—four times as large as Asia, ten times as large as North America, more than one-third of the entire surface of the globe—one and a third times the area of the entire land surface of the world. Its width along the equator between the mainland of Asia near Singapore and South America is practically half the circumference of the globe and nearly four times as wide as the North Atlantic. Nor is the Indian to be classed among the minor oceans.

Australia and New Zealand are the dominant and almost the only commercial factors in the South Pacific and Indian oceans.

The Routes of Australia. The problem of Australian routes is fundamentally different from that of Africa. There is no populous rain-drenched interior, with mighty rivers tumbling with the power of a flock of Niagaras over the margins of a continental plateau. About all that can be said in a commercial way of much of Australia is that it is on the map. It is an immense arid and semi-arid stretch with a good eastern margin and a fair but small southwestern corner. Large tracts in the central and western parts have never been crossed by any explorer, and many explorers have perished in attempted explorations. The agriculture is practically all east of the Pacific watersheds except a little in southern Australia and a few irrigation settlements; and by the time the western boundary of New South Wales is reached the desert becomes practically absolute and even the hardy sheep herder must give up.

The most spectacular route in all Australia is the transcontinental railway line running for more than a thousand miles across the desert and connecting the railway systems of South Australia and Western Australia. It was built by the federal government, because obviously no other agency would undertake such an unprofitable enterprise through hundreds of miles of uninhabited and unproductive arid waste. There are several days between trains. Another route for the transmission of ideas, not goods—the desert telegraph line erected at great



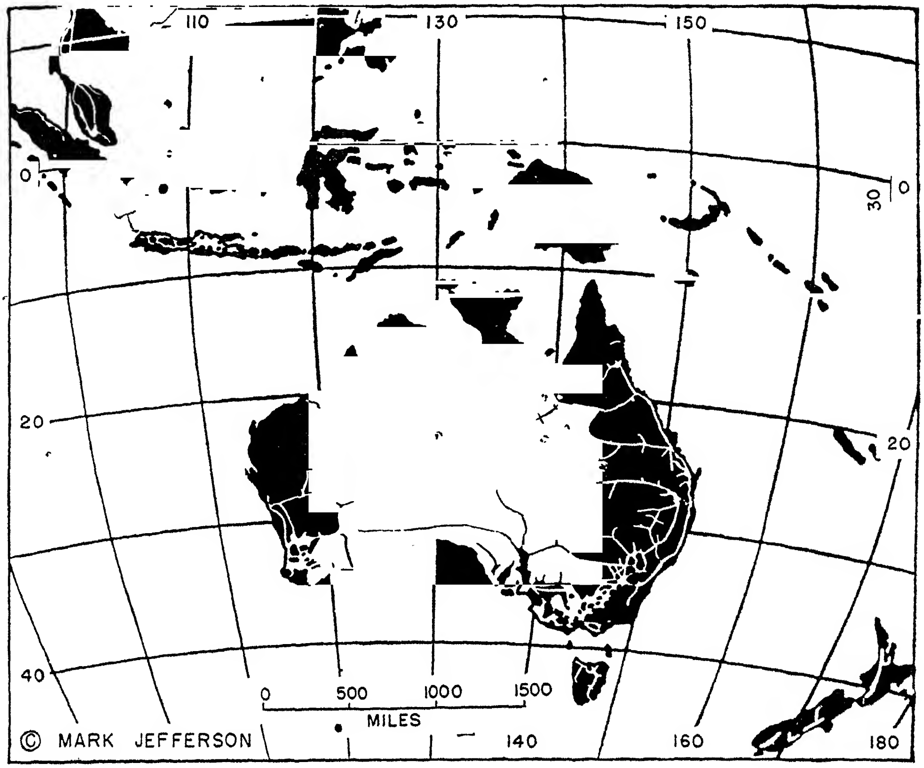
This map and those on pages 904-905 go far to being an economic geography of Australia. This unfortunate continent has a lot of tropic territory, but it is not far enough into the tropics to have a great tropic river valley like the Congo or the Amazon. It is the sister, rather, to North Africa with its Sahara.

It is a semi-comical fact that the business groups of the cities on the east coast, living in the land of good rain, have great difficulty in admitting that much of Australia is desert. They prefer to call it "undeveloped" and they are of course quite right—it is indeed undeveloped.

hardship across the center of the continent to the north shore—connects there with the Asiatic cable system and Europe. As yet no transcontinental railroad spans the country north and south.[1] During World War II a modern motor highway was completed across the desert between Alice Springs and Birdum, thereby connecting the railroads that extend inland from Adelaide on the south and from Darwin on the north, but this rail-and-highway route is solely of military importance and serves no commercial need. The next most spectacular thing is the pipe line which carries water from the mountains back of Perth (Western Australia) many scores of miles eastward into the desert to the gold diggings of Coolgardie and Kalgoorlie.

After passing through a stage in which mineral production was paramount in Victoria and important in New South Wales, these two states have

[1] The Commonwealth Government has pledged itself to build a railway connecting Port Darwin on the north, the port of the Northern Territory, with the railway system of South Australia. It is estimated that this railway expenditure will amount to about $50,000,000. This Northern Territory has about one-sixth of the total area of Australia. Except for the small settlement at Port Darwin, it has scarcely any white population, most of it being an empty wilderness. There is small evidence of the keeping of that political promise.



The habitability map is almost a perfect explanation of this railway map. The desire of a country of continental size to have transport connection between its important parts led the United States Government to subsidize very heavily the first transcontinental railway. Similarly, Australia built that long railroad line across deserts, between the settled areas of the southwest and the southeast. This was sheer waste because the ocean alongside gives so much cheaper transport, and the airplane overhead now gives faster transport for fast mail and travelers in a hurry. As to defense, such a railroad line could not possibly be kept open in wartime without control of the air.

The early talk about a railway connecting the extreme north with the extreme south has apparently died away since the enthusiasm vented itself on the desert railway of the south. During World War II, a truck road (so-called) was built as an emergency protection measure. In times of peace, it will doubtless have many ruts and little service. It is too much like a road across the Sahara.

grown into great pastoral regions. Both have developed excellent railway systems, 6,100 miles in New South Wales and 4,700 miles in Victoria. Their ports, Sydney (pop. 1,311,000) and Melbourne (pop. 1,077,000), have a surprising concentration of the population of the two states—at the present time one-half of all the people being in these two ports. This seems to be a condition common in regions that have done most of their growing up in the railroad era, and a duplicate is found in our Pacific coast and in Argentina. The good harbor seems to get the start; the railways are built there; trade centers there; and this advantage of an early start gives no other place a chance to make a beginning. In Australia the additional political advantage of ports being state capitals is also an important factor in letting the ports monopolize the trade

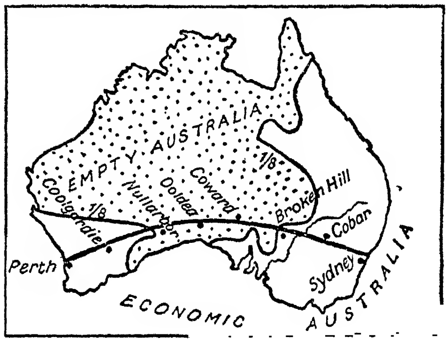
of large states. Intercity jealousy caused the Commonwealth of Australia to go into the wilderness and spend tens of millions of dollars building Canberra, a new city where no one wants to live—a foolish feat of politics.

Adelaide (pop. 325,000) stands in a like relation to the best section of South Australia, and its railroads are practically a continuation of those of Victoria.

The almost unsettled Queensland, with its long coasts, has more ports and far less railroad mileage. The chief port is Brisbane, a city of 336,000—about one-third the population of the state—which does much of its trading through Sydney, with the assistance of coasting steamers which do an important trade in Australia. The whole northern and northwestern coast is scantily inhabited, and the trade of Western Australia is handled chiefly at Perth (with its harbor at Freemantle), which has a railroad to the gold-fields in the desert.

Australia's Trade Connection with the Rest of the World. Australia is practically at the other side of the world from the United States and Great Britain, and is at the end of all routes that reach it—the European mail route that comes down from Ceylon where it leaves the Mediterranean Asiatic route, the smaller branch line that threads its way from Singapore through Torres Strait to Brisbane and Sydney, the freight lines that pass Good Hope, and the steamer lines from the Pacific coast of the United States and Canada.

From a traffic standpoint the Good Hope route far outweighs all others as a freight route. Australia sends over this line to Great Britain wheat, frozen meat, wool, hides and skins, butter, gold, and lead. In return for these staples come British machinery, cotton goods, woolen goods, and a whole list of manufactured articles that are required by a highly civilized agricultural community doing but little manufacturing. By far the most valuable export is wool—sometimes making up



The thing to note about this map of Australia is the empty area—bounded by two curved lines that mark the limits of the central area, having less than an eighth of a person per square mile. The straight line with the eight named points on it, shows the location where eight photographs were taken, said photographs are to be seen in the introductory part of Griffith Taylor's excellent book, *Australia*. Professor Taylor, a geographer, does not agree with the Chamber of Commerce Party in Australia.

one-third of the total—followed by gold, butter, meat, wheat, flour, lead, fresh and dried fruit, hides and skins, and various ores. Consequently, the Australian imports of lumber, wood pulp, petroleum, chemicals, machinery, and miscellaneous manufactures sometimes make more tons than the export; and the vessels in Australia are in straits for out-freight. This situation is mostly found in the port of Sydney, which is due to its being the terminal port for nearly all vessels going to Australia, and the natural end of a voyage. Fortunately for the vessels seeking profitable em-

ployment, Sydney has the great advantage of being near the Australian coalfields at Newcastle but 60 miles away. This lack of other export freight has placed Australia in a position to ship coal from the east coast as a ballast substitute. It is carried to Java, Singapore, and even Indian ports.

The traffic from eastern United States via Panama to Australia fills many ships a year and is largely composed of automobiles, iron and steel products, Gulf Coast sulfur, tobacco, agricultural and other machinery, and a host of miscellaneous small articles. From our Pacific Coast we ship large quantities of petroleum products and lumber. We import but little from Australia except wool and hides and skins.

New Zealand. New Zealand, long narrow islands with a row of good harbors, exceeds Australia in the simplicity of its inland routes. Invercargill, Dunedin, Lyttleton, Wellington, Napier, and Auckland—all have short railways to the farms and ranches. It differs from Australia in that it has a much better rainfall, making luxuriant pasturage. Hence it has become the world's largest exporter of cheese and the second of butter. Otherwise it is a smaller edition of Australia in its exports and imports, which are predominantly with Britain, which is the place where half the property of British Australasia is still owned, the natural market for the products and the place that many Australasian families still think of as the old home.

Most European and American liners serving New Zealand also call at Australia's great ports, Sydney and Melbourne. There are good local steamship lines between the various Australasian ports.

Australia and New Zealand are frequently referred to as the Antipodes, and rightly so, for they lie at the tail-end of the world's longest trade routes. The ports of New Zealand and Australia are served by passenger and cargo liners coming from Europe via Suez; by tramps, general cargo liners, and refrigerator vessels from Europe moving via the Cape of Good Hope; by liners from eastern America and some from northwestern Europe via Panama; and by tramps and liners and tankers from the west coast of Canada and the United States. In addition, there is a small but growing trade around the western Pacific with Japan and China. Finally, there is the little used route, the path of an occasional tramp, via Magellan Strait.

2. *Routes Across the Pacific*

The Element of Distance. Although Australia and New Zealand are upon the edge of the Pacific, their commerce has surprisingly little to do with that ocean except along its edges. As a result of its enormous size, the rather surprising fact develops that the Pacific Ocean is practically not crossed by any important trade routes—they skirt its edges. (A globe is necessary for correct impression.) We have already seen in the account of the North Pacific trade route how that route follows the shores of the American and Asiatic continents from Panama to Singapore. The trade of South America, prior to the opening of the Panama Canal, moved down the Pacific shore to creep out of that ocean through a hole in the mountain wall—

the Strait of Magellan. Tramp ships laden with Australian coal swing across the southern margin of the ocean to the nitrate ports and then follow the shore. Even the route from Australia to Panama, in taking advantage of the great circle, swings so far to the southward that it passes between the islands of New Zealand and follows much nearer the edge than the middle of the ocean. Some scattering vessels—chiefly tramps, go with Australian coal into the North Pacific, but the only trade route in all this great ocean that may really be said to cross it, is that connecting Australasia with the Pacific coast of North America.

The ports of Vancouver, Seattle, San Francisco, and Los Angeles are connected with Australia and New Zealand by several lines of steamers. Two of these call at Hawaii and one at Tahiti, in the Society Islands. This is at present the quickest mail route from Australia to Europe because it uses the fast trains of America and the North Atlantic steamers, but the commerce consists chiefly of outbound lumber and wood pulp from British Columbia, Washington, and Oregon and petroleum products from California.

Winds and Sailing Vessel Routes. In most parts of the ocean the Pacific is well suited for the sailing vessel. In its northern and southern parts the trade winds blow as in the Atlantic, and to the north and south of these wind areas are the same zones of the west wind. The working out of the leading South Pacific vessel tracks shows most plainly the effect of these winds. The winter route from Sydney to San Francisco, for example, goes to the south of New Zealand and nearly 2,000 miles east of it before turning northward into the trade winds. By this deviation the sailing vessel can pass through the southern trade winds almost before the wind and take an approximately right-angle course across the northern trade-wind zone. The summer route between these same two ports shows the effect of the same winds, but also shows that the zones have shifted somewhat to the north with the movement of the seasons. The fact that the trade winds always blow away from the coast of lower and southern California makes it necessary for all sailing-vessel tracks into San Francisco to make a wide detour to the north to avoid the trades and come in before the west wind.

The two great defects of the Pacific as an ocean for the easy development of sailing routes are the large zone of calms in the equatorial region west of South America, and the ferocious storms of the Cape Horn region. The sailing-vessel route from San Francisco to Callao in Peru is a striking example of the influence of the doldrum or calm zone, to avoid which the vessel passes nearly 2,000 miles to the west of its destination and more than 1,000 miles to the south of it to get the proper angle to sail across the trade winds and entirely avoid the zone of calms, in which the vessels idly drift for days together. There have even been cases of whaling ships which have started from the southern hemisphere to make the northern whaling season and have entirely missed it by floating for months like seaweed in the doldrum calm.

The winds around Cape Horn blow with a force rarely met elsewhere, and almost continually from the west. In addition to this, snows and storms are of exceedingly frequent occurrence, and

it was by no means uncommon for vessels to spend ten, twenty, or even thirty days in almost the same spot, beating vainly against the wind which would not let them round the cape from the Atlantic into the Pacific. This accounts for the fact that the sailing vessels regularly went to Australia from the Atlantic by way of Good Hope and returned by Cape Horn, and there are cases of vessels that have tried to get into the Pacific around Cape Horn, and after vain effort have given it up and gone eastward before the west wind to reach Chile or California. In the early days of steamers to Australia, the Peninsular and Oriental Steamship line (British mail) used to send its steamers home from New Zealand by the Straits of Magellan, thus regularly circumnavigating the globe, although no South American freight was sought except that of the Chilean port of Puntarenas in the straits. The route was selected because of the greater ease of steaming with wind and current and has now been given up in this period of more powerful and economically operated steamers.

The Fuel Supply. For steamers, the coal supply of the Pacific is better than one might expect from a consideration of the mere factors of size of the ocean and length of the routes. At each of the four corners of the Pacific is a coal-field —Japan, British Columbia, east Australia, and Chile, although Chilean coal is not good for bunker fuel, most of it being used on government-owned railroads. The central Pacific throngs with unnumbered islands, many of them having good harbors, and about five of them being coaling stations. These are New Caledonia, Fiji, Samoa, and, to the north of the equator, Guam and Hawaii. Of these islands, not one, however, is regularly used as a coaling station by an important line of steamers, the common practice being for the regular vessels to proceed from mainland to mainland without adding to their stocks of coal. But each of the above-mentioned coal-producing regions at the ocean's corners possesses important coaling stations for ocean steamers. On the long routes of the Pacific oil is used exclusively by vessels engaged in liner service, oil from the East Indies, California, and Peru.

The Future Traffic of the Pacific. In the future as in the present, the mid-Pacific promises to remain a realm little crossed by trade routes and bare of industry or the hope of industry. A vast stretch of ocean lying between New Guinea, Hawaii, and Japan is large enough for two or three continents, but absolutely uncrossed by any trade route worthy of the name. In this empty sea a new island might remain undiscovered for decades unless some whaler, or some investigating Drake or Darwin chance to sight it, or World War II be repeated. With the exception of Hawaii, the only Pacific island producing large quantities of freight is the French island of New Caledonia, not far from Australia. The exports of nickel and other ores from this island furnish employment for a considerable number of vessels homeward bound from Australia. With these two exceptions, the vast Pacific is bare of islands which are capable of supporting commerce in any large modern sense. The myriads of coral islands are almost uniformly low and comparatively barren. Most of them are

unpeopled, and those that are inhabited produce little but the coconut palm. The lands upon its southwestern edge partake of the inhospitality of its middle, for New Guinea and adjacent islands are almost entirely undeveloped except for a few coconut plantations. It is small wonder that about the only vessels visiting these shores are those of the copra-gathering and rum-selling traders. The adjacent part of Australia, Queensland, has one city of 336,000, but its population density is less than 2 inhabitants per square mile; Australia's Northern Territory averages one seventy-fifth of a person per square mile; so most of the shore of northern Australia is of little more use to civilized man than is the middle of Borneo, or a section of Amazonian forest five miles from a river, or a part of Canada inland from Hudson Bay—all of which are essentially unused.

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Suez and Panama: Vital Gateways of Commerce

1. *The Development of Trade and Transportation at Suez*

The Elements of Time and Place. Man is continually seeking short-cuts as he pursues his eternal conquest of space. The digging of two canals, first at Suez and later at Panama, provided ocean-going vessels with short-cuts resulting in enormous savings in distance, time, and money. The Suez Canal afforded a new gateway to the Indian Ocean; the Panama Canal, a new gateway to the Pacific. The completion of canals at Suez (1869) and at Panama (1914) brought about the greatest shifts in ocean routes since Columbus' discovery of the New World and da Gama's discovery of a sea route to the Orient. Both at Suez and Panama the need of a canal had long been recognized, for each isthmus was the site of a long established transshipment trade. In each case, however, the problems of construction were different, and the opening of a canal wrought different effects upon shipping and trade. The Suez Canal was built in the halcyon days of sail at a time when steam navigation was still in its infancy, while the Panama Canal was completed in an era of steam when the doom of the sailing vessel was fully apparent.

Early Commerce via Suez. Down through the ages the narrow isthmus of Suez has been a traffic bottleneck between East and West. It is said that as early as 2500 B.C. the Egyptians had dug a canal from the lower Nile to Great Bitter Lake and thence to the Gulf of Suez at the head of the Red Sea.[1] In time this ancient canal either silted up through neglect or was deliberately filled in to prevent enemy use, and for centuries all trade between the Mediterranean world and the Orient was conducted by overland caravans. In 1498 Vasco da Gama reached India via the Cape of Good Hope, and six years later the Venetians planned a canal at Suez but never completed it.[2] From the time of da Gama until the middle of the nineteenth century overland traffic languished at Suez, and the Cape route remained the prime route to the distant Orient.

The Advent of the Steamship and Railroad. In the eighteen-forties steamer service was established between London and Alexandria and between Suez and Bombay, resulting in a lively transshipment trade between the Mediterranean and the Red Sea. This trade consisted

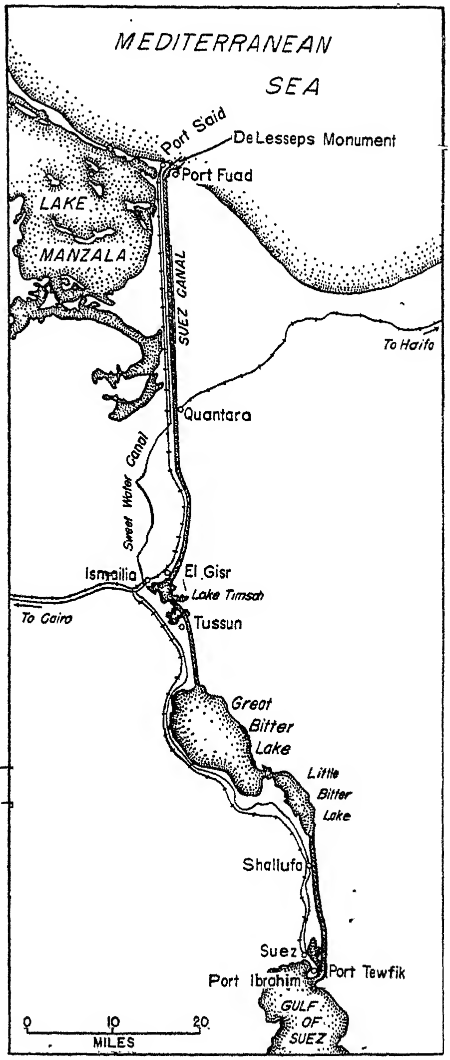
[1] See Charles A. Fayle, *A Short History of the World's Shipping Industry*, George Allen & Unwin, Ltd., London, 1933, pp. 36-37, and William O. Blanchard, "Suez—Mediterranean Backdoor Entrance," *Jl. of Geog.*, vol. 42, March, 1943, p. 91.

[2] See Adam W. Kirkaldy, *British Shipping: Its History, Organisation and Importance*, Kegan Paul, Trench, Trubner & Co., Ltd., London, 1919, p. 291.

of passengers, mail, and small parcels of high-valued freight. In 1845 mail from London was delivered in Bombay in 45 days. The journey via Suez was hardly one to attract mere tourists. At Alexandria the passenger was transferred to a primitive river steamer, and he was provided with a small amount of miserable food, given the privilege of washing in the ship's bucket, and charged about £15, or about $75, for the 170-mile trip up the Nile. At Cairo he was often packed with 6 or 7 other passengers in a cart and hauled 80 miles to Suez at a fare of £12, or about $60.[3] Thousands of camels and donkeys were used to carry both men and goods across this 80-mile stretch of desert. In 1854 a British company completed a railroad from Alexandria to Cairo and extended the line to Suez four years later. Although the railroad was a great improvement over previous modes of transport, the isthmus remained an impediment to commerce, for transshipment was expensive. As commerce increased, the need for a canal became apparent.

Construction of the Suez Canal. The planning and successful completion of the Suez Canal was almost entirely the result of the genius and perseverance of one man, Ferdinand de Lesseps, who served as French consular agent in Egypt from 1831 to 1838. On November 30, 1854, de Lesseps obtained from the Khedive of Egypt a concession to build the canal, and in the following year he organized a canal company and sold 400,000 shares of stock, over half of which were sold in France, most of the remainder being purchased by the Khedive of Egypt.

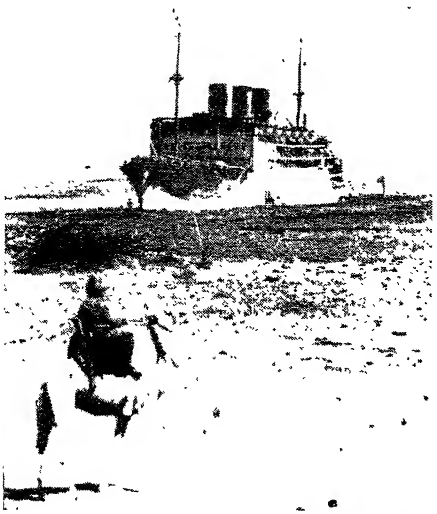
Excavation was begun near Port Said in April, 1859, but the canal was not opened to traffic until November, 1869.



This map shows one of the true bottlenecks of world trade. The sweet water canal fed from the Nile shows the extreme levelness of the country and its greatest need. During World War I a pipe line started somewhere in this area and carried water far into Palestine for the support of Allenby's British Army.

[3] Arthur J. Sargent, *Seaways of the Empire*, Adam & Charles Black, Ltd., London, 1930, pp. 48-49.

The long delay in completing the canal was caused by strong opposition from the British, who owned the desert railroad and were anxious to dominate the affairs of Egypt and who through own-



Black Star Photo

Two ships of the desert. The man on the camel is a member of the Egyptian Coast Guard. The world ocean has thousands of miles of desert shores. The huge steamer with three stacks is not stuck in the sand. It is proceeding through the Suez Canal, which luckily man could make by scooping out sand in a level land for most of the way. It was a very easy job to do.

ership of Cape Colony controlled the competitive route to India. British shipping authorities denounced the canal project as impracticable, the British public refused to invest in the canal company, and British statesmen placed many obstacles in de Lesseps' path.[4] At this time Egypt was under the suzerainty of Turkey, and British pressure caused the Sultan of Turkey to withhold approval of de Lesseps' concession for 12 years, after it had been granted by the Khedive of Egypt. Indeed, not until the canal had been in operation for two years did Great Britain dispatch its India mail via the canal, but shortly thereafter the majority of all ships transiting the canal were British vessels. It was one of the dramatic moments of history when on November 25, 1875, Benjamin Disraeli, Britain's prime minister, purchased 176,602 shares of canal stock from the Khedive with £3,976,580 borrowed from Baron Rothschild and then sold them to his government.[5]

In contrast with the political obstacles to the building of the Suez Canal, the engineering problems were simple. A sea-level canal was feasible, as most of the canal was dug through a low plain of sand and mud, shallow lakes accounting for more than a third of the distance between the Mediterranean and the Gulf of Suez. Nearly all of the initial work was done by a great army of laborers with picks and shovels, donkeys and camels being used to carry away baskets full of dirt. Since the isthmus affords no fresh water for man and beast, camels were used at first to carry Nile water to the project at a cost of about $2,000 a day. Eventually a "sweet water" canal replaced the caravan trail, and it is still used to deliver fresh water from the Nile to points along the ship canal. The big ditch has been subsequently widened and straightened, and its banks have been reinforced against washing and cave-ins. From time to time the depth has been increased, and the canal

[4] ~~See Charles~~ W. Hallberg, "Suez Canal," *Encyclopaedia of the Social Sciences,* vol. 14, The Macmillan Co., New York, 1934, pp. 444-445.

[5] In 1945 Great Britain owned 295,026 of the 652,932 shares outstanding. For more than 50 years dividends on canal stock have never been less than 25%, and in some years they exceeded 50%. It is probable that the British Government never made a more profitable investment.

now accommodates vessels drawing 32 feet of water. In 1885 the installation of electric lights permitted the use of the canal at night. As a result of improvements, the average time of transit through the canal has been reduced from 48 hours in 1870 to 11½ hours at present.

2. *The Development of Trade and Transportation at Panama*

Early Transshipment Trade. While no ancient canal was ever built at Panama, early proponents were not lacking. It is said that pioneer voyagers to Panama advised Philip II of Spain of the advantages of piercing the isthmus, but Philip dismissed the scheme, because his spiritual counselors suggested that what God had joined together man must not rend asunder.[6] Like Suez, the isthmus of Panama was a natural traffic focus. For more than three centuries of Spanish rule all trade between the west coast of South America and the mother country was routed via Panama. The treasure of Peru was brought to Panama and carried on the backs of Indian porters and mules across the rocky isthmus to Puerto Bello to await the sailing of the "silver fleet," which consisted of well-armed vessels that always sailed in convoys. Later a wagon road was built, but the need of better transportation was clearly demonstrated in the early eighteen-fifties when thousands of Americans lost their lives from tropic disease in Panama while endeavoring to reach California to dig gold.

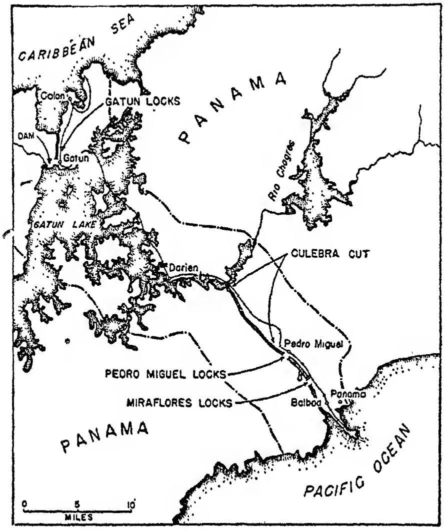
The Panama Railroad. In 1855 the world's first and shortest transcontinental railroad was opened to traffic across the isthmus of Panama. The project was completed with the aid of Chinese labor at a cost of $7,500,000 and at a terrific cost of human life. In those days yellow fever, malaria, and dysentery were horrible mysteries, and it is often said that there was one dead Chinaman for every tie in the 47½ miles of roadbed. From the time it was built until it was eclipsed by the great canal, the railroad handled a lucrative transshipment trade.[7] Although the railroad reduced the time and cost of transit, the necessity of transshipping goods across the isthmus remained. In 1898 the need of a canal was made clear to every citizen of the United States when our battleship *Oregon* was forced to make the 14,000-mile voyage from San Francisco around Cape Horn in order to join the American fleet just before it sailed from Key West to defeat the Spanish fleet near Santiago, Cuba.

Construction of the Panama Canal. Two attempts were made to build a canal at Panama. The first resulted in abject failure; the second, in one of the greatest engineering triumphs of modern times. In 1878 a French syndicate obtained a concession from the Republic of Colombia, which then owned the isthmus of Panama. Four years later the company, now headed by Ferdinand de Lesseps of Suez fame, began the excavation of a sea-level canal. The

[6] Adam W. Kirkaldy, *op. cit.*

[7] Prior to the opening of the canal, at least 80% of all Ecuadorean cacao exports were shipped on liners to Panama for transshipment by rail across the isthmus and thence by liner to Europe and the United States. Today the prime function of the railroad is the carriage of imported freight to Panama City and the movement of supplies within the Canal Zone, as most vessels unload cargoes for Panama at Colón and no good highway has yet been built across the isthmus.

company issued stocks and bonds with a par value of $475,000,000, but these were sold at large discounts and yielded



The terrain for the Panama Canal was something very different from the level, sandy, rainless area through which the Suez was scooped. It was in the tropical forest and hilly land, almost mountainous, subject to torrential downpours. One of the great fears of the engineers who planned it was its ruin by the floods of the Chagres River, which drained most of the course of the canal. In the northwest corner of the map, the dam shows where the Chagres was dammed to make Gatun Lake and where spillways let the surplus water on down the great river while the canals cut across to the town of Colon.

If this had been a rainless area, the canal could only have been a sea level canal, like the Suez. It takes great quantities of water to fill the locks every time a ship goes up or down, but the Chagres River, the Gatun Lake and the reservoir at the right center of the map provide plenty of water. Water for the top level of a canal is often a vexing problem.

only $278,000,000. About $118,000,000 was actually spent on construction, $19,000,000 for the purchase of the Panama Railroad, and $141,000,000 for interest on bonds, extravagant salaries, luxurious offices, public endorsements by financiers, and the support of newspapers. In 1889 the company was forced into bankruptcy—a result of financial mismanagement, corruption, failure properly to appraise engineering difficulties, and failure to provide sanitary working conditions in a disease-ridden jungle.

Where de Lesseps failed, the United States Government succeeded. After much discussion of the relative merits of the Panamanian and Nicaraguan routes, Congress authorized President Theodore Roosevelt to buy out the de Lesseps company and to pay Colombia $10,000,000 cash for the canal site, plus an annual rental of $250,000. A treaty was signed with Colombia in January, 1903, embodying these terms, but the Colombian Congress wanted more money and adjourned on October 31, 1903, without ratifying the treaty. Then a series of important events occurred with remarkable rapidity. The people of the state of Panama were deeply disappointed at the failure of the Colombian Congress to ratify the treaty, and two distinguished Panamanians decided to organize a "quiet" revolution, which occurred on November 3. American warships were on hand to prevent the landing of Colombian armed forces. Indeed, our Acting Secretary of State cabled for information about the reported revolution two hours and twenty minutes before it began. The next day the Republic of Panama was organized; two days later it was officially recognized by the United States; and twelve days later a treaty was signed with the new republic, guaranteeing its political integrity and giving it the purchase price and annual rental for the canal

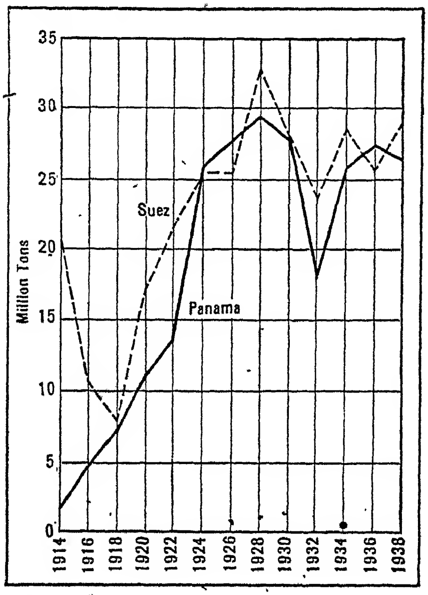
site which Colombia had refused to accept. Like the great Disraeli, Theodore Roosevelt knew a good thing when he saw it, acting promptly and explaining afterward.

The United States Army Corps of Engineers decided upon a lock canal instead of a sea-level project and began work on May 4, 1904. Colossal quantities of dirt and rock were excavated with the aid of steam shovels, high explosives, and Jamaican Negroes. The task of construction involved the building of three sets of twin locks (Gatun, Pedro Miguel, and Miraflores), the creation of a huge artificial lake (Gatun), the use of one natural lake (Miraflores), and the control of landslides at Culebra Cut where the canal passes through a low dip in the mountains. It is doubtful whether Colonel G. W. Goethals and his able engineers could have succeeded in their cyclopean task without the aid of Colonel W. C. Gorgas and his medical corpsmen. In the short lapse of time following the collapse of the French enterprise the tropical world had begun to enter a new epoch, for it was discovered that yellow fever and malaria were borne by mosquitoes. Gorgas and his men waged incessant war against the mosquitoes. Crude oil was spread upon the streams; swamps were drained or oil-coated; and trees and tall grass were cut down around every work camp so that the sea breezes might have free sweep to drive the mosquitoes away. As a result, the death rate at Panama was reduced from one of the highest to one of the lowest in the world. On August 15, 1914, the canal was opened to traffic.

A ship entering the lock on the Panama Canal. In the background we see the forested hills. The size of the thing is indicated by the figure of a man, namely, the second dark object in the center path on the structure at the right. The tug which tows ships in harbors is replaced by heavy locomotives on tracks alongside the locks. One is visible in the center, also the rope that ties it to the ship.

3. The Commercial Significance of the Two Canals

Effects of the Suez Canal upon Trade and Shipping. The Suez and Panama canals have the same *raison d'être,*



Suez and Panama traffic. Comparison of tonnage carried by the two canals. Figures prior to 1920 were greatly disturbed by World War I. After 1924, when normal conditions had been established, it is interesting to note how closely the two traffic figures approach each other.

namely, to save the shipping industry distance, time, and money. For 15 years prior to World War II, the two canals handled approximately the same volume of traffic, although the net tonnage of vessels passing through Suez was usually a little larger than at Panama (see Fig. 916). In virtually every other respect the two canals are different.[8] Both canals have now been in operation long enough for their commercial significance to be clearly appraised.

The opening of the Suez Canal saved approximately 4,500 nautical miles on the voyage from London and Liverpool to Bombay as compared with the Cape route, 3,000 miles to Yokohama, and 1,000 miles to Sydney. The short-cut to the Orient resulted in a lowering of prices of many commodities and a great increase in trade.[9] It also served as a stimulus to the construction of larger steamships with more powerful engines, both liners and tramps. From the beginning, the canal has been of greater importance to India than to points farther east, for ships clearing from Bombay and Calcutta save more distance by using the canal than do ships sailing from Singapore, Batavia, Sydney, Hongkong, and Yokohama. The canal has meant much more to the countries of Europe than to the United States. It has been of greater importance to the liner than to the tramp.

The liner aims at speed, and virtually all liner traffic between European ports and those of Asia and Australia is routed via Suez. The tramp seeks economy, and its routing is very sensitive to changes in freight rates. When rates are high, more tramps use the canal. When they are low, tramps avoid the canal tolls and follow the cheap route via the Cape.[10] Of the total net tonnage

[8] See Arthur J. Sargent, *op. cit.*, pp. 80-96.

[9] Between 1870 and 1880 the rice and wheat exports of India to Europe more than doubled. Between 1870 and 1884 the price of many Eastern products declined from 25% to 35% on European markets. The price of Australian wool dropped, but to a less degree.—*Ibid.*, pp. 53-54.

[10] Prior to World War II, merchant vessels were charged 5¾ francs (gold) per net ton if loaded, nearly 3 francs per net ton if in ballast, and an additional toll of 10 francs for each passenger over 12 years old and 5 francs for each child between the ages of 3 and 12. A tramp steamer of 5,000 net tons had to pay a toll of 28,750 francs, or about $5,700.

of shipping moving south through the canal, usually less than 10% is tramp tonnage. While liner tonnage accounts for most of the northbound traffic, the dominance of liners is not so great, because large quantities of foodstuffs and raw materials from India move northward by tramp through the canal to the great urban markets of Europe. Virtually all tramps clearing from Australian ports for Europe follow the Cape route, and those clearing from ports east of India are likely to do so if freight rates are low. British ships normally account for well over half of the number and tonnage of all vessels using the Suez Canal.[11]

Effects of the Panama Canal. As in the case of Suez, the opening of the Panama Canal radically changed the distance element in the applied geography of transport. For example, it saved approximately 7,900 miles from New York, 8,900 miles from New Orleans, and 5,700 miles from Liverpool on the voyage to San Francisco by eliminating the long trip around Cape Horn (see Table 48). Eastern North America and northwestern Europe very definitely gained as a result of the opening of the canal, for they were placed much nearer by steamer route to all of western North America, western South America, and New Zealand. For eastern North America the canal has meant a great reduction in the distance to Japan and to all of China north of Hongkong, a factor that has unquestionably contributed to the rapid growth of our trade with eastern Asia. Above all, the Panama Canal greatly stimulated trade between western and eastern United States, and it opened up an entirely new economic vista to the whole west coast of South America, virtually tying that region commercially to the east coast of the United States.

The Panama Canal is almost as definitely American in its function as the Suez Canal is British. In most years more than 40% of the total tonnage moving through the Panama Canal has been American tonnage.[12] There is an important difference, however. The British merchant marine ranks second in the use of the Panama Canal, while the use of the Suez Canal by American vessels is indeed small. In 1938 1,780 American vessels of 9.9 million net tons and 1,281 British vessels of 7.3 million net tons passed through the Panama Canal, while 2,939 British vessels of 17.0 million net tons and only 67 American vessels of 0.4 million net tons moved through Suez. In yet another respect the two great canals are different. The Cape of Good Hope offers important competition with Suez, while the Cape Horn route has very little traffic and is a sorry substitute for Panama.

Since World War I many liner services have been established via Panama. The Japanese built up liner services between eastern America and Japan, and the British operate many direct services from the United Kingdom to ports on the west coast of North and South America and to New Zealand. Furthermore there is no tramp tonnage under the American flag. In view of these facts, it is doubtful whether tramp tonnage accounts for as much as a

[11] Millions of net tons of merchant ships using Suez in 1938: British, 17.0; Italian, 4.3; German, 3.1; Dutch, 3.0; French, 1.7; Norwegian, 1.5; Greek, 0.8; all other, 2.2.

[12] Millions of net tons of merchant ships using Panama in 1938: American, 9.9; British, 7.3; Norwegian, 3.3; Japanese, 1.8; German, 1.5; Danish, 0.9; all other, 3.1.

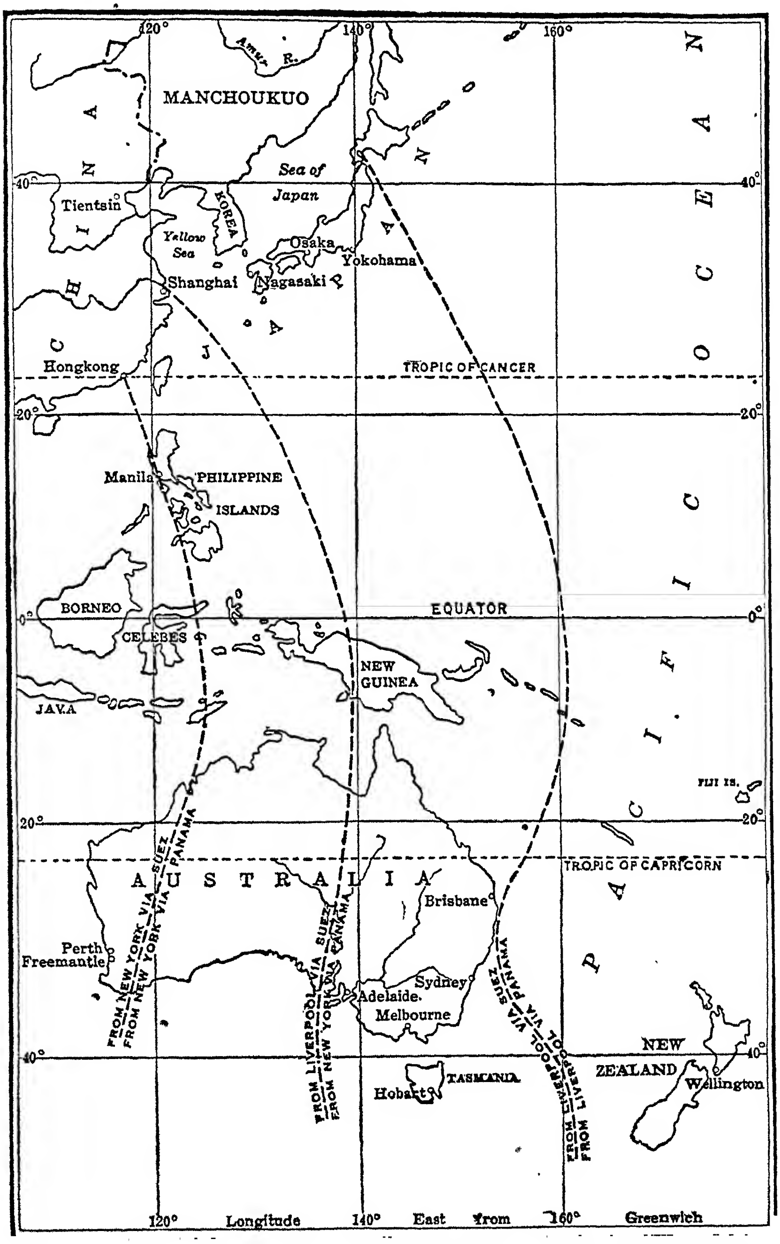
fourth of all vessel tonnage passing through the canal.

Suez Versus Panama. The long routes from Suez and Panama meet and cross in the Far East and Australasia. Ships going from Liverpool to the Far East find it shorter via Suez to points along the Asiatic coast as far north as Vladivostok and at least as far east as Sydney and Brisbane. But ships from New York find it shorter via Panama to points along the Asiatic coast as far south as Hongkong and as far west as Albany, Australia. Therefore, there exists a "twilight zone," or overlapping competitive area that is served by both Suez and Panama (see Fig. 919). Within this area competition between American and European goods is apt to prove very keen. It must be remembered, however, that other factors such as quality of goods, credit terms, prices, and tariffs may offset the advantage of distance. Furthermore, a matter of five or six hundred miles on a twelve-thousand-mile sea voyage does not materially alter freight rates, for freight rates are determined more by the amount of return cargo and the amount of way-cargo en route than by mere mileage. Hence, it is difficult

TABLE 48

SAVINGS BY THE PANAMA CANAL

	Nautical miles	*Days at 10 knots*	*Days at 16 knots*
Liverpool to Port Townsend	5,666	23.1	14.2
Liverpool to San Francisco	5,666	23.1	14.2
Liverpool to Honolulu	4,403	17.8	10.9
Liverpool to Valparaiso	1,540	5.9	3.5
Liverpool to Yokohama	−694	−2.4	−1.3
Liverpool to Shanghai	−2,776	−11.0	−6.8
Liverpool to Sydney	−150	−.6	−.4
Liverpool to Adelaide	−2,336	−10.8	−6.1
Liverpool to Wellington	1,564	6.0	3.5
New York to Port Townsend	7,873	32.3	20.0
New York to San Francisco	7,873	32.3	20.0
New York to Honolulu	6,610	27.0	16.7
New York to Valparaiso	3,747	15.1	9.2
New York to Yokohama	3,768	15.2	9.3
New York to Shanghai	1,876	7.3	4.4
New York to Hongkong	−18		
New York to Manila	41		
New York to Sydney	3,932	15.8	9.7
New York to Adelaide	1,746	6.7	4.0
New York to Wellington	2,493	9.9	6.0
New Orleans to San Francisco	8,868	36.4	22.6
New Orleans to Yokohama	5,705	23.3	14.4
New Orleans to Valparaiso	4,742	19.2	11.8



The lines on this map tell their own tale—interesting tale—and show the area of competition between the two canals. In this area rate cutting might shift trade.

to forecast the relative importance of Suez and Panama as gateways to this twilight zone.

The Canals at War. Strategically the Suez Canal has long been of great importance to Great Britain, and the Mediterranean-Asiatic route has long been called the "lifeline of the Empire." During World War I half of all British ship losses from submarine warfare occurred in the Mediterranean Sea, and while large amounts of shipping had to be diverted to the Cape route, the "lifeline" was not cut. During World War II the German invasion of North Africa and heavy bombing of shipping from Italian islands compelled the diversion of merchant shipping to the Cape route for many months. The canal was well guarded against air attack, but if a ship had been sunk in the canal, it would have been a relatively easy task to excavate a passage in the sands of Suez around the sunken ship.

During World War I one of the major functions of the Panama Canal was to facilitate the shipments of Chilean nitrate to the United States and our allies. Unfortunately, the canal was closed to traffic from September 18, 1915, to April 15, 1916, by landslides. In World War II the Panama Canal played a major role, for the United States and its allies were confronted with the power of Germany in Europe and Japan in the Far East. It has been recently revealed that from July 1, 1941, through June 30, 1945, 23,008 vessels transited the canal.[13] These included 8,010 ocean-going merchant vessels, 1,212 small commercial vessels, and 13,786 vessels exempt from tolls, chiefly our warships. During this period more than 45,000,000 tons of cargo were carried through the canal. The Panama Canal was unquestionably one of our greatest wartime assets. We guarded it well, and it served us well in winning a difficult war with Japan.

[13] "The 'Big Ditch' Reveals Its Secrets," *The New York Times Magazine,* Nov. 18, 1945, p. 6.

The World's Airways

1. The Air Age

Our Shrinking World. The "last word" may never be written in the annals of man's conquest of space. At present no place in the world is more than 40 hours away! This simple, startling fact is the achievement of men who build and fly planes. It reveals how nations are shrinking to neighborhoods, how distant frontiers are losing their mystery. Mountains, oceans, deserts, jungles, and polar icefields are no longer the same barriers to transportation and trade. Travel by air is now measured in hours and minutes rather than in hundreds and thousands of miles. We are compelled, therefore, to revise many of our geographical and other concepts as the world enters a new epoch, the Air Age—the Age of Terror. 'Tis pitiful to think that by far the greatest of all the results of air transport is terror. Will some new robot of the air drop unannounced bombs and kill me and a few million others some early night or some early day? Once 'twas said, "Uneasy lies the head that wears a crown." Now uneasy lies the head of all mankind, due to man's own devilish inventions—the atom bomb and the radar guidance of manless air vehicles of destruction.

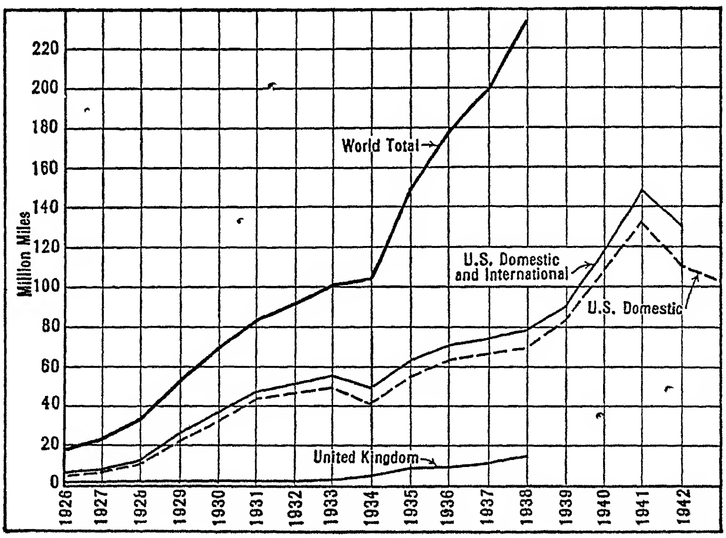
Unlike those who traverse the earth's surface, the aviator is able to follow the arc of a great circle, the shortest route between any two points on the globe. In contrast with the mariner, the aviator is no respecter of coastlines. He encounters no bottlenecks such as Malacca and Gibraltar, Suez and Panama. To him every city and town, whether it be inland or coastal, is a potential port of call. His navigable ocean is the air, a universal ocean extending to the threshold of everyman's door.

The great mail-order houses of Chicago are not yet shipping their wares regularly by air to customers all over the world, but in many remote areas the Air Age has surely arrived. In some places man has shifted suddenly from the most primitive to the most modern means of transportation. Surprising amounts of food, supplies, and mining machinery are delivered by plane to mining communities in interior Alaska and the North Woods of Canada, lands of the snowshoe, dog sled, and birch bark canoe. Denizens of the Amazonian forest who have never seen a wheel, have seen the airplane fly over. The Andean countries of South America are passing directly from pack-trains of llamas and mules to the airplane, aerial freight including lumber, fuel, radios, refrigerators, barbed wire, heavy machinery, galvanized iron, and even cattle and sheep. Caravans of dusky porters in Darkest Africa now gaze at winged caravans in the sky. Many natives of New Guinea, Siberia, and China have never seen a locomotive, steamboat, or motor truck, but they know the cargo plane well.

Some countries possess large areas beyond the reach of railway, waterway, and highway. The importance of aviation to such areas is shown by the fact that in 1938 about 47,800 tons of freight moved by air in the Soviet Union, 13,100 tons in New Guinea, 9,700 tons in Canada, 7,500 tons in Honduras, and 6,200 tons in Colombia, as compared with 3,700 tons in the United States. The cultural impact of the airplane upon remote peoples is often tremendous. To the Eskimos of northern Canada the airplane now brings such varied articles as outboard motors, repeating rifles, sewing machines, and ladies' girdles. For good or for evil, we live in a rapidly shrinking world.[1]

We have seen that on the North Atlantic speed, comfort, and luxury in ocean travel have been developed to a supreme degree. In contrast with the tiny *Mayflower* that delivered its cargo of famous ancestors and antique furniture in 65 days, the luxury liners *Queen Elizabeth* and *Queen Mary* make the run from Bishop's Rock (Southampton) to Ambrose Light (New York) in a little less than 4 days. Early in 1946 Pan American Airways installed new Constellation planes on its transatlantic run, each of these luxury airliners carrying 43 passengers from New York to London in less than 13 hours. By fastest bomber Europe is only 5½ hours away! Death leads!

Growth of Air Transportation. Commercial aviation is a new and rapidly



Miles flown by carrier planes—world total, United States and United Kingdom, 1926 to 1943. The overwhelming weight of the United States in this showing is one of the many ways of illustrating the wealth and physical power of this country. This should be regarded as a responsibility.

A Japanese admiral, six years stationed in the United States as purchaser for his government, was retired before World War II because he insisted that ~~Japan~~ could not succeed against such weight of material.

[1] See Wendell Willkie, *One World,* Simon & Schuster, New York, 1943, and Waldemar Kaempffert, *The Airplane and Tomorrow's World,* Public Affairs Committee, Inc., New York, 1943.

expanding industry. In 1939, only 12 years after Lindbergh's memorable flight from New York to Paris, the world was spanned by airways. Regular airline service extended from London to such distant points as Sydney, Singapore, and Capetown; from Paris to Saigon and Tananarive; from Berlin to Rio de Janeiro and Kabul; from Amsterdam to Batavia and Paramaribo; from New York to Buenos Aires, Lisbon, and London; and from San Francisco and Los Angeles to Honolulu, Auckland, Manila, and Hongkong.

In the early 1930's most industries were bogged down in a business depression, but commercial aviation and the manufacture of aircraft continued to expand. Between 1930 and 1938 the total distance flown by the world's scheduled airlines increased at an average rate of 17% per year. In 1938 these commercial lines flew 233,756,000 miles, or more than treble the mileage of 1930 and twelve times that of 1926.[2] Only a new and aggressive industry could achieve such a meteoric rise (see Fig. 922).

The great pioneer lines of international aviation were the Pan American Airways, the German Lufthansa, Air France, the British Imperial Airways, and the Royal Netherlands Airways. All of these commercial lines received mail subsidies or other forms of governmental aid. Pan American operated 62,000 miles of scheduled air routes abroad in 1939 and about 99,000 miles in 1941, a greater route mileage than any of its competitors at the outbreak of the war.[3]

In the prewar development of air transportation the United States played a leading role. In 1938 our *domestic* airlines possessed only 10% of the route mileage of the world, but they accounted for 30% of the total miles flown.[4] They carried 1.3 million passengers, or more than the Russian, German, British, Dutch, Australian, French, and Canadian airlines combined. The ton-mileage of mail service performed in this country was surpassed only by British airlines, which served not only the United Kingdom but also European and long Empire routes.[5] The movement of air express or freight in the United States, however, was comparatively small, as all of it (3,700 tons) could have been loaded into one railway freight train.

As our nation girded itself for defense and later for war, nearly all of our aircraft output was needed by our Armed Forces and for Lend-Lease. Very few new planes were available for commercial use at a time when the demand for air transport was growing rapidly. Between 1938 and 1944 the number of commercial planes in scheduled service and reserve in the United States increased from 253 to 279, the length of

[2] See Joseph B. Hubbard, "World Transport Aviation," *Harvard Business Review*, vol. 22, no. 4, 1944, pp. 509-515.

[3] In 1938 Russia had 71,000 miles of air routes, nearly all of which were domestic. For a history of Pan American Airways, see Matthew Josephson, *Empire of the Air*, Harcourt, Brace & Co., New York, 1944. Also see Henry L. Smith, *Airways: The History of Commercial Aviation in the United States*, Alfred A. Knopf, New York, 1942.

[4] Million miles flown by scheduled airlines in 1938: United States (domestic), 69.7; United States (international and territorial), 8.5; Germany and Austria, 15.0; United Kingdom, 14.3; Australia and New Guinea, 11.1; Canada, 10.9; France, 8.8; Netherlands and Netherlands Indies, 7.6; Brazil, 3.1; Mexico, 3.1.—Joseph E. Hubbard, *op. cit.*, p. 511. Note: no comparable data for Russia.

[5] In 1938 British airlines carried first-class mail to Empire destinations at a rate of 1½ pence, or 3 cents, per ounce, as compared with a rate of 6 cents in the United States.

domestic air routes grew from 35,000 to 40,000 miles, but the distance flown rose from 70,000,000 to 142,000,000 miles. The number of passengers increased from 1.3 to 4.7 millions, while express and freight traffic mounted from 3,700 to 33,000 tons.

Between 1938 and 1944 commercial air transport in this country witnessed a fourfold increase in passenger-miles, a sevenfold increase in the ton-mileage of mail, and an eightfold increase in the ton-mileage of express and freight.[6] Such was the record of service rendered by our domestic airlines during an era of stress.

2. *Air Technics, Politics, and Economics*

Technological Progress. Present traffic along the world's airways is a result of technological achievements of the past. From the time that the Wright Brothers' tiny flying machine tottered into the air in 1903 until the present day inventive genius has faced the problems of building good planes and motors and surmounting the hazards of the weather. These problems now appear to be nearly solved.

At the conclusion of World War I most of the world's airplanes were made of wood, linen, and glue, although in 1919 "defeated" Germany was operating transport planes built of duralumin, an aluminum-copper alloy twice as strong but only one-third as heavy as steel. During the 1920's the biplane gradually gave way to the monoplane, and the streamlined thick wing evolved. In 1926 the bone-shaking, tri-motored, all-metal Ford transport, capable of carrying 8 passengers, was hailed as the marvel of its time.

During the 1930's wood gave way to metal in plane construction, and greater streamlining was achieved. More powerful and reliable engines were built, and much better fuel was used. The instrument panel became scientific, radio communication was improved, robot pilots permitted blind flying, and radio beams made blind landings safe. Well-lighted and well-marked airways and airports appeared throughout the world.

Between 1930 and 1945 the power output of airplane engines increased from about 500 to more than 2,000 horsepower. The maximum speed of transport planes increased from about 125 to 350 miles per hour, while the range of flight rose from 500 to 4,000 miles. During this period the weight of the plane grew from about 12 to more than 50 pounds per square foot of wing area, a nearly fivefold increase in the usefulness of the airplane as a carrier of weight.[7]

The perfection of many new inventions during the war has greatly improved the aviator's ability to cope with the weather, his most unremitting and unpredictable foe. Among them is an anti-icing device that circulates hot air from the engine into the wings and tail surfaces, thereby preventing the formation of ice at any time. Another achievement is radar, the magic eye that guides a plane through storm or fog and gives

[6] Transportation service performed by domestic airlines in 1944: 2,264 million passenger-miles, 51 million ton-miles of mail, and 17 million ton-miles of express and freight.—Howard Mingos (ed.), *The Aircraft Yearbook for 1945*, Lanciar Publishers, Inc., New York, 1945, p. 432.

[7] See "New Transport Planes," *Fortune*, vol. 32, June, 1945, pp. 131-136 ff., and July, 1945, pp. 141-144 ff.

warning of an unseen object ahead.[8] High altitude flight permits man to fly above the weather, especially on long-distance runs. However, even stratosphere planes are earth-bound, since upon landing and departure they must face such hazards as icy runways, sudden thunderstorms, and gusts of violent winds.

At the outbreak of World War II the most widely used commercial transport in this country was the Douglas DC-3, a 12½-ton, 21-passenger plane with a cruising speed of 195 miles per hour and a range of 1,700 miles. During the war Boeing's Stratocruiser was used as the Army's C-97 transport, a 65-ton, 100-passenger plane with a cruising radius of 340 miles per hour and a range of 3,500 miles. At the close of the war much larger and faster planes had been designed for commercial aviation, and they may be built.

So rapid has been the progress of aeronautical science within the last few years that lurid fantasy becomes accepted reality almost overnight. Nobody knows the answers to such questions as: How big? How fast? How high? How far? These technical questions are no longer important, as planes can now be designed for almost any purpose. The big questions about planes of the future are: What will they carry? Where will they go? At what cost? For present-day international aviation an even greater question is: Who owns the air?

Political Hazards. Technically, the world is ready for a great expansion of international aviation. Politically, it is ill prepared. Today the greatest obstacle to the growth of international air transport is the prevailing doctrine of national sovereignty, each nation stubbornly insisting that it owns the air above its territory to an indefinite height. In practice this means that foreign planes cannot land within a nation's limits unless previously granted permission by treaty, franchise, or some other arrangement.

The pioneer airmen who made around-the-world flights were forced to seek the aid of their governments in obtaining rights of passage from every country that they intended to cross. The establishment of commercial air routes across international boundaries was preceded in almost every case by hard-fisted bargaining and often by prolonged diplomatic disputes. "An eye for an eye, and a tooth for a tooth" was (and still is) the order of the day. A few examples may be cited.

In the prewar era Turkey closed its skies to all foreign planes. German airlines, except for a few experimental flights, were excluded from North America, and for some years they were kept out of France. Franco Spain admitted German and Italian airlines but barred the British, French, and Dutch. For a time Great Britain blocked a French air route to Indo-China, although it gave the Dutch flying rights over India in return for the privilege of an air route to Australia via the Netherlands East Indies. A few tiny countries, because of strategic locations, forced foreign airlines to pay exorbitant fees for

[8] The new radio altimeter also affords greater safety in navigation. Whereas the old altimeter recorded only distance above sea level, the new altimeter throws radio waves down and registers distance above the ground by the "bounce," or reflection. Indeed, the new device is so sensitive that it reacts violently when a plane flying down the Hudson River clears the Washington Bridge by 800 feet.—Henry L. Smith, *op. cit.*, p. 365.

landing rights and also to provide lucrative jobs for the local citizenry.

All nations joined the cut-throat game of aeropolitics. The United States closed the air of Hawaii to all foreign planes, thus making prewar trans-Pacific flying an American monopoly. In retaliation, Australia denied entry to our Pan American Airways. In 1936 this American line was admitted to British Hongkong only after it had acquired landing rights in Portuguese Macao about 70 miles away. In 1935 Pan American was ready to cross the North Atlantic but was not allowed to enter Great Britain until 1939, after it had obtained landing privileges in the Azores, Portugal, France, and Eire. In December, 1945, Pan American cut its New York-to-London passenger fare from $572 to $275, and the British, fearful of competition, immediately restricted Pan American flights to two a week instead of five.

For those who are unable to bargain successfully, "freedom of the air" is but an empty phrase. As yet the air policy of every nation is a mixture of commercial and military expediency. National governments are well aware that the airplane is a terrible instrument of warfare as well as a vehicle of commerce. In the Air Age of today we are all neighbors (that is, we are near enough to be), but in an era of atomic bombs and instantaneous destruction we are potentially neighbors-in-Hell, or possibly Heaven.

Petty nationalism remains the greatest liability of the twentieth century. Those who believe in international cooperation are agreed that there must be some yielding of sovereign rights, some merging of national powers, some willingness to accept the decrees of a World Air Administration—if the peoples of the world are to reap the full benefits of modern aviation and still preserve the peace.[9]

Economic Obstacles. The chief disadvantage of the airplane is that it is a poor carrier of weight. Seldom does the revenue load amount to 25% of the total loaded weight of the plane. Some things are simply too heavy, too bulky, and too low in value to be handled by airplanes. Not even aviation's most ardent enthusiasts predict that grain, coal, cotton, timber, iron ore, and similar commodities will move in appreciable quantities by air.

Only in regions where modern transport facilities are lacking or where competitive freight rates are high, as in the Andean countries, northern Canada and tropical forest areas, does the airplane become a truly economical carrier of machinery and other items of heavy freight. The great bulk of the world's air traffic consists of passengers, mail, and express. These compact, high-valued cargoes can afford the cost of high speed. The limitation of the airplane as a carrier of weight is shown by the fact that the average weight per shipment by air express in this country in 1944 was only 19.3 pounds.[10]

During the war the Army's Air Transport Command operated the world's longest freight line, spanning

[9] See Keith Hutchison, *Freedom of the Air*, Public Affairs Committee, Inc., New York, 1944; Adolph A. Berle, Jr., "Freedoms of the Air," *Harper's Magazine*, no. 1138, March, 1945, pp. 327-334; and Edward Warner, "The Chicago Air Conference," *Foreign Affairs*, vol. 23, April, 1945, pp. 406-421.

[10] In 1939 the average weight was 6.7 pounds. Major items moving by air express were small machinery and hardware, printed matter, store

the globe in 116 hours of actual flying time.[11] The ATC moved vast quantities of supplies over long distances at high speed but with *no* regard for cost. The commercial air transport company must have a high regard for expense.

Speed and frequency of service are the airplane's two prime assets. Hence, the handicap of a small unit load may be partially offset by fast and numerous trips, and an airline may render a remarkable amount of transportation service during the course of a year. Erelong airplanes carrying 150 passengers or 40 to 50 tons of cargo will be used on transoceanic flights, but the bulk of the world's air traffic will be handled by smaller planes making frequent trips.

Each year we travel farther, faster, and more cheaply by air, and the same tendency is true in the movement of air express or freight. Nobody can predict the volume of international air traffic during the coming decade. The answer depends upon politics as well as economics. Will the world's statesmen be able to achieve Freedom of the Air?

3. *Airways of the Future*

Great Circle Routes Versus Detours. Opposed to the geographical truism that the arc of a great circle is the shortest distance between any two points on the globe is one hard economic fact, namely, that "the longer way around may be the most profitable way out." In the air, as on land and sea, transportation agencies tend to avoid "traffic deserts" almost as nature abhors a vacuum. Hence, the detour is often preferred to the direct route.

At the present time commercial aircraft do not ordinarily fly great circle courses. Rather, they fly from airport to airport along airways serving traffic producing and consuming areas. It is on long non-stop flights that the distance-saving great circle routes are of maximum importance.

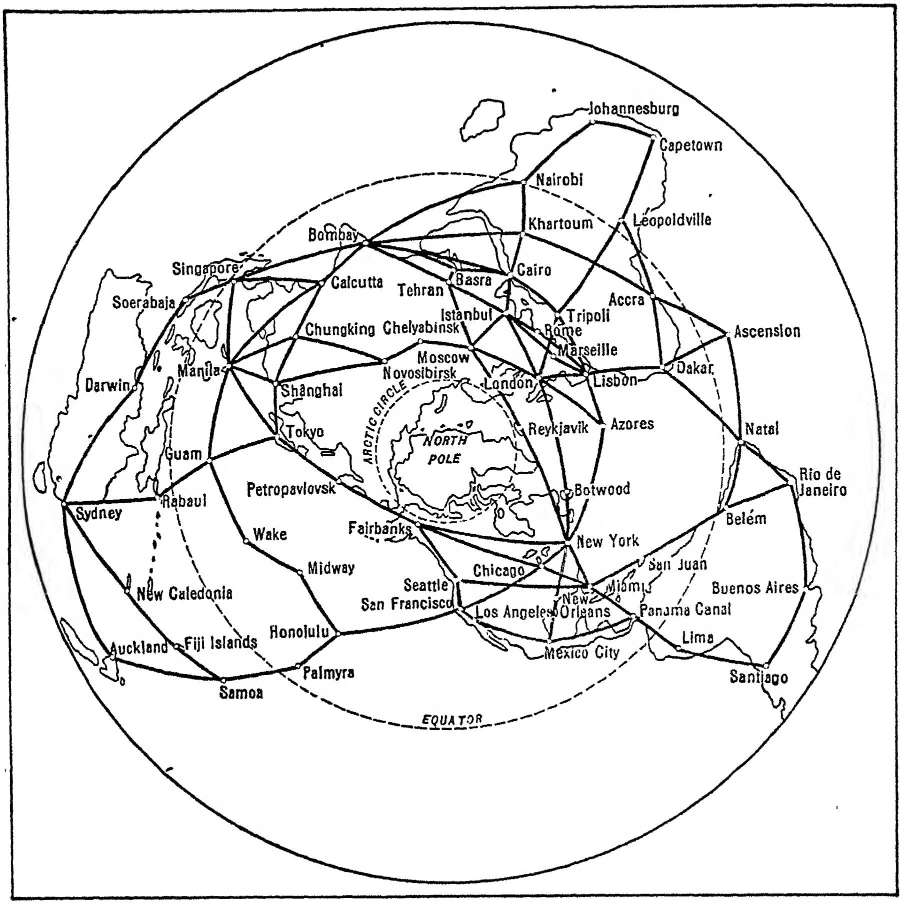
Prior to the war, when planes were smaller and weaker, the great oceans were usually crossed by circuitous hopping from mainland to island to island to mainland. Today our huge transport planes can make 4,000-mile non-stop flights with ease. Indeed, the chief justification of the mammoth plane lies on journeys of upwards of 4,000 miles—to places that many Americans still regard as "uncivilized." It has been suggested that erelong planes of 200-passenger capacity will be used for intercontinental travel, that planes carrying 50 to 60 passengers will be employed on transcontinental flights, while 12- to 18-passenger planes will be used for feeder lines and local service.[12] With the development of long-distance stratosphere flights, great circle routes will play an increasing role.

The world is now spanned by a vast network of airways (see Fig. 928). Some of these follow great circles rather closely, while others do not. If political obstacles to international aviation can be

merchandise, electroplates, transcription records and radio parts, news photos, freight manifests and other documents, movie films, cut flowers, personal baggage, optical and photographic supplies, food, drugs, and liquor.

[11] See "The World's Greatest Airline," *Fortune*, vol. 32, August, 1945, pp. 159-164 ff., and "The New Air Age," *The New York Times Magazine*, November 4, 1945, pp. 6-7.

[12] On trips up to 5 hours the human animal is content to sit still. Between 5 and 10 hours he must have space to go to bed. From 10 to 20 hours he must have freedom to roam. Hence, on long non-stop flights big planes are needed to provide creature comfort and also to carry a big fuel load.—"The New Transport Planes," *Fortune*, vol. 32, July, 1945, p. 177.

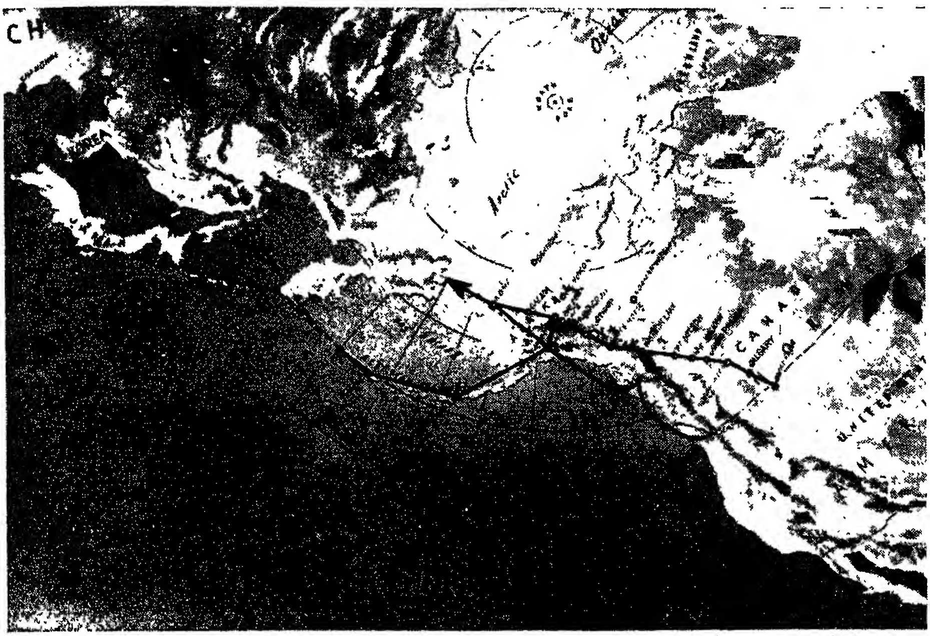


The air routes that are especially important in the period immediately after World War II. They show the basis for the statement that no place in the world is now more than 40 hours away from any other. A person looking at this map should also look at the pole-centered map on page 746 which does not exaggerate areas beyond the equator so much as this one does. Notice the salamander shape of Australia.

removed or alleviated, some of these airways will emerge as great trunk-lines of commerce. Other routes will be no more than "country roads" of the air. Fundamentally, the importance of each air route will be determined by the interplay of five factors: (1) potential traffic between terminals and along the route, (2) the length of the route, (3) the longest unavoidable non-stop flight, (4) the availability of airports and other facilities, and (5) weather conditions.[13] Of these, the traffic factor will be dominant.

The importance of traffic as a location factor may be shown by a single illustration. The trans-ocean airway between San Francisco and Manila via Hawaii, Midway, Wake, and Guam is 8,000

[13] See J. Parker Van Zandt, *The Geography of World Air Transport*, The Brookings Institution, Washington, 1944, p. 22.



Press Syndicate Photo by Ruth Robertson

This photograph of part of a globe shows two skyways from the United States to Japan. From two take-offs in the United States, Seattle and Great Falls, Montana, two routes meet at Nome, where the arrow indicates the direction followed by the Russians in the air transport of supplies and equipment during World War II.

miles long. The great circle distance is 6,965 miles, but to follow the circle would involve a non-stop flight over the open sea for almost the entire distance, passing 1,650 miles north of Honolulu and about 700 miles south of the Aleutian Islands. A third and more practical route avoids the watery desert and extends northward through Portland, Seattle, and western Canada into Alaska and Siberia and southward through China to the Philippines. This overland route from San Francisco to Manila is 245 miles shorter than the island route and 790 miles longer than the great circle, but its traffic potentialities are far greater. Air traffic, like that of the sea, will be *around* the North Pacific, not across it. (See a globe. All flat maps tell lies, because they lie flat!)

The Hemisphere That Matters. The earth is round, but the fact is that we live in a very lopsided world. One-half of the world, known as the "land hemisphere," contains nearly nine-tenths of the world's ice-free land and a preponderant share of the world's natural resources, technical skill, and financial power.[14] Here are concentrated 94% of the world's people and 98% of all industry.[15]

Within the land hemisphere are to be found four trading areas of utmost importance: (1) Greater Europe, includ-

[14] The precise center of the hemisphere containing the maximum amount of land is southeast of Nantes, in western France. (For a map of the world with London as the center, see Fig. 746).

[15] J. Parker Van Zandt, *op. cit.*, p. 4.

ing North Africa and Asia Minor, (2) North America, north of the Rio Grande, (3) Soviet Russia, and (4) nearly all of the remainder of continental Asia. The extent to which these trading areas dominate the world's economy is amazing. These four zones possess 59% of the world's land area and 88% of the people. They account for 81% of the total railway mileage, 85% of the cultivated land, 91% of the total earned income, 92% of all cities of over 100,000 population, 94% of the automobiles, and 95% of the factory output.[16] It is reasonable to conclude that airways on and between the Eurasian and North American continents will carry the bulk of all air traffic in the future.

The Position of the United States. By geographical accident France, Great Britain, Holland, Belgium, and Germany cluster about the center of the world's land hemisphere. They have the advantage of the shortest air routes to most of the world's land. Western North America, most of South America, South Africa, and the eastern and southern Asiatic mainland lie near the periphery of the land hemisphere. Beyond the periphery are New Zealand, Australia, the Philippines and East Indies, and southern South America. Those countries far from the center of the hemisphere will have to fly their passengers and cargoes farther, on the average, to foreign markets than those located near the center. As far as the element of distance is concerned, the position of the United States is less favorable than that of northwestern Europe.

The distance factor is of considerable importance, since the operating costs of airlines vary more directly with distance than those of railroads and ocean shipping companies. Distance, however, is only one factor in the equation of trade. Above all, the kind, volume, and direction of trade depends upon the productivity and purchasing power of peoples —the availability of resources per capita.

We have seen that the greatest of all overseas trade routes is the North Atlantic route, connecting northwestern Europe and northeastern United States. These two regions far surpass the Oriental centers of population in output per man, purchasing power per capita, and total volume of trade. The North Atlantic promises to be the greatest of all trunk-line routes of the air, and the United States will be a major participant in the trade.[17]

A glance at the political map of the world reveals how poor the United States is as an owner of air bases for a globe-encircling merchant marine of the air. With worldwide flying ambitions, our possessions and territories offer little in contrast with the far-flung British Empire and the vast Russian domain. Indeed, we are poor in comparison with the French, Dutch, and Portuguese—inheritors of empire.[18]

On the vital great circle routes leading to the north,[19] we must petition for landing rights from the Canadians, Russians, and Chinese. Perhaps the most

[16] *Ibid.*, p. 21.

[17] See Waldemar Kaempffert, *op. cit.*, p. 3; Burnet Hershey, *Skyways of Tomorrow*, Foreign Policy Association, Inc., New York, August, 1944; and Blair Bolles, "The Future of International Airways," *Harper's Magazine*, vol. 188, January, 1944, pp. 97-106.

[18] For excellent maps of the airway empires of the United States, Great Britain, France, and Portugal, see Joseph Kastner, "The Postwar Air," *Life*, vol. 15, November 1, 1943, pp. 102-104.

[19] See Elmer Plischke, "Trans-Arctic Aviation," *Econ. Geog.*, vol. 19, July, 1943, pp. 283-291.

. . . 37

Geography and Some Trends in Man's Affairs

1. The Age of Invention

We stand on the threshold of a new age. We stand on the threshold of the golden age of material and comfort, or perhaps we are standing on the brink of crashing, calamitous destruction. Which? That depends upon ourselves.

Let's postpone the discussion of destruction. The golden age is more pleasant to contemplate, though perhaps a bit harder to bring into being.

Said the serpent to Eve in Eden, as they looked up into the tree that bore the forbidden fruit, ". . . in the day ye eat thereof, then your eyes shall be opened and ye shall be as gods, knowing good and evil."

Eve and Adam did eat. Their eyes were opened, they became as gods, and troubles followed.

Perhaps we are like them. Perhaps science is the forbidden fruit, certainly it tastes good. Certainly it has given us many good things, certainly also it bringeth trouble in the form of bombs, atomic and other.

As to our new powers through science —in the last forty years we have invented or discovered or introduced on a grand scale:

1. The passenger automobile and motor truck
2. The tractor
3. The airplane
4. The Diesel engine and oil-driven ship
5. The radio
6. Radar
7. The science of genetics
8. Synthetic fibers
9. Synthetic rubber
10. Plastics
11. Winning of products from the water of the sea
12. High-speed steel—the mother of the assembly line and the real age of machinery.

There are many others just around the corner already proving themselves, but not yet on the scale of this above-mentioned dozen.

That is a stupendous list for one generation to witness. It is science that has brought us to the threshold of this new and pregnant age—pregnant, but what will the offspring be? If good, it may be very, very good, but look at World War II, the atomic bomb, and imagine what would have resulted if Hitler had got it first. Think on that for five minutes.

2. *New Power, New Machines, New Manufactures, New Resources*

Perhaps mechanical power and machines have been adequately presented

in other chapters in this book, but we wish to call attention to a dictum of the late Thomas A. Edison, "Give us an order large enough and we will make automatic machines to turn out the product." We merely wish to call attention to the fact that Edison's dictum can be illustrated in hundreds of factories, where more and more products are being transferred from the special machine with the machine tender to the standardized automatic machine that is fed from a hopper and works in connection with moving belts and assembly line.

In recent decades physics and chemistry have stepped forward as industrial partners of the standardized machine in its new process of mass production. We live in a scientific age.

The medieval alchemist strove to transmute common things into gold, but the present day chemist does things which would perhaps be more astounding to the medieval alchemists and certainly are more productive of economic benefit to mankind.[1] For sheer astonishment take the nylon in which many women display their form. This beautiful and durable fabric is made of fiber which traces back through many processes to black coal, common air and common water, but not of necessity! The chemist can also make it out of petroleum and vegetable oils.

Nature made a little red insect which lives on a tropic plant. Men grew the plant, caught the insects that fed upon it, and had an industry with a salable product—cochineal, a beautiful red dye. The chemist made the same red out of ill-smelling, ugly coal tar. By the same process, he made synthetic indigo and destroyed the indigo industry, and now synthetic vanillin cuts in on the vanilla industry. The chemist also made artificial silk which cuts in on the natural silk industry. What fiber will the chemist and the physicist not duplicate? Is there any limit to what they can do?

Nature produces in many plants latex, from which we produce rubber; but probably your automobiles are, at this moment, running on synthetic rubber, made from petroleum or from corn or some other grain that produces starch.

The combinations of carbon and hydrogen, called hydrocarbons (C_2H_3, C_3H_4, C_4H_5, etc.) are so nearly limitless that the Bituminous Coal Institute now claims "there are 200,000" products derived from coal.

The chemist finds his basic raw materials in the minerals, such as mercury, zinc, sulfur; in air and water; and he is now discovering that the plants, too, are a greater mine of raw materials for him than he had suspected. The chemist can do many things, but he has to turn to the plants to get starch, sugar, cellulose and protein. A great botanist has pointed out that plants hold the basic patents on these and then he averred, slightly figuratively of course, that from

[1] The medievalist, whether alchemist or conquistador, overestimated gold. The Spanish conquerors wrecked, sacked and murdered in Peru to get the Inca hoard of gold and silver. It has been said that it supported the Spanish monarchy for centuries, but some economically minded person recently pointed out that all the gold that Spain got from Peru in the three centuries of her dominance was not so valuable as the guano deposited by the seabirds on the little string of desert rocks called Chincha Islands, just off the coast of Peru. The Incas were smart enough to protect these birds for the valuable fertilizer which nourished the crops on the irrigated lands of the Peruvian desert valleys in the pre-Columbian era, as they do today.

The real alchemists are the men of this generation who learned how to extract nitrogen from the air and thus feed the plants that feed us.

these four the chemist can make almost anything.

The chemist's partner is the chemical engineer. The chemist discovers a process, makes the miraculous new thing in a test-tube. It is quite another job to make the devices that will run continuously, perhaps automatically, and operate these same processes in quantity that gives industry a new, cheap material. The chemical engineer starts with a test-tube process. He works for years and at the end starts the raw materials into one end of a plant that covers a city block. The materials pass through filters, pumps, driers, through pipes, retorts and vats, changing as it goes, until it gets on conveyors and at last goes out in drums or sacks, at the far end of this long building, a usable product, ready to be loaded into truck or freight cars and become the basis of some other industry.

During this last forty years of advance in science and technology, the material at our disposal has remained static except for some small additions of meteoric material and large reduction through destruction by the acts of man.

While the actual *material* at our disposal is static or declining, and must continue to do so, our *available* resources are increasing rapidly. Man is a tool-using animal, and every important new tool enables him to use something not used before, to make a new industry or an old industry in a new place. Every important invention alters the sum total of resources available to man, and it changes his relation to some part of the earth on which he lives. The steamboat, the train, and the tractor are good illustrations of this change in man's relationship to the earth.

3. *Some Effects of the Advance of the Power Age*

While we depended upon the beasts of burden for most of our non-human power, the American people remained clustered along the Atlantic coast and the navigable rivers (for flat boats) that drained the Atlantic slope. The steamboat opened the Ohio and Mississippi valleys to rapid settlement about 1820, and the people from the Atlantic slope and Europe swarmed into the Mississippi Valley. The railroad soon followed and between 1840 and 1870, we settled commonwealth after commonwealth in the middle of the continent, but the horse still did our farm work for us, with a little assistance from the ox.

Consider wheat, the great international food staple. If the horse does the work, he is needed for only six or eight weeks of work in producing the grain crop; but he must eat for twelve months. If there is a crop failure every third year he must eat for thirty-six months in order to make two crops; and if there is a failure every other year, he must eat forty-eight months in order to make two crops. Despite their months of necessary loafing, these helpers get tired when they work, and must rest. They get hot, they get sick, they go lame, the harness rubs them sore. The farm tractor does not get tired, it does not eat when it is not working, and we have improved it to the point where it rarely goes lame. It can go night and day, and in the rush season a man who has had a long period of rest can work fifteen or sixteen hours a day for many days. Then someone else can take his tractor and, with our present knowledge of lighting, keep it going throughout

the night. One man, instead of driving three, four, or even eight horses, turns on the power of twenty, forty or sixty horses that will work twenty-four hours a day. The acreage of level plain that a family can plant with this new help is several times as large as that within the reach of man aided merely by beasts. It is now claimed that in level Iowa, a man, with the latest tractor, can plant, cultivate and harvest 120 acres of corn and a much larger acreage of wheat in the wheat belts of the Great Plains.

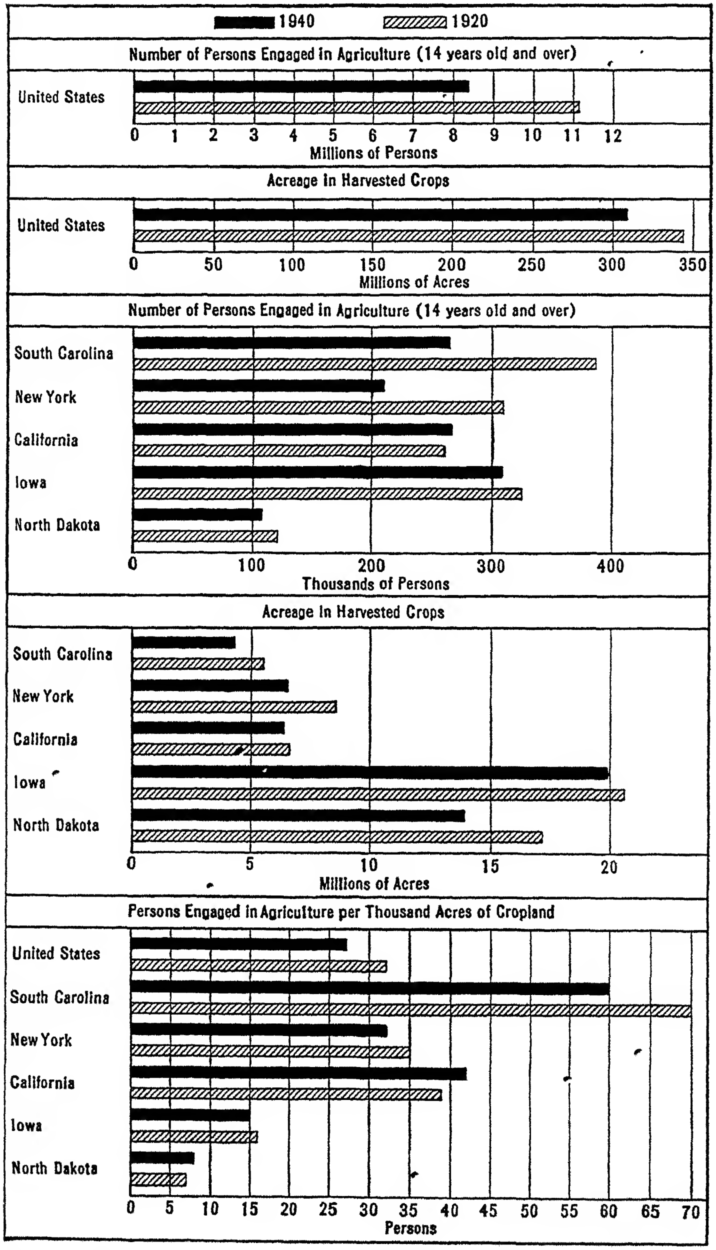
This enlarged acreage means reduction in the cost of grain growing. It means that wheat can be grown in lands that we before thought worthless because of the uncertainties of rainfall, or frost. Take the case of some experiments at Cheyenne, Wyoming, which in three seasons produced respectively 9.3, 7.8, and 37.6 bushels because of the difference of four inches of rain in the growing season. The average was 18.2. Four of the low crops and one of the high would still average 14.3, a figure that looks well among national averages, made possible by one good season in five. Such farming would scarcely be profitable with the aid of beasts, but it is easily practicable with the aid of the tractor.

In lands of low rainfall it has been well proved that the wheat yield can be increased in quantity and certainty by the practice of summer fallowing, which means plowing the land one year and raising the crop the next. By this means no plant is allowed to grow during the fallow season and the water which would otherwise evaporate through the growing plants (a surprising amount) remains in the subsoil, where it welcomes the next year's rainfall and combines with it to water one good crop out of the two years' supply. One trouble with this system is that it requires much cultivation. It is easy to see how the tractor helps at summer fallowing and so has pushed the wheat fields out into the lands of little rain and of frost. The tractor enables wheat growing to become a dependable business in climates where the horse farmer could not consider it because of drought. Thus farms, towns, and food-supply are now found in places which were not thought of as farm lands in the days of first settlement.

It is not surprising that the wheat problem of world commerce from 1926 to the outbreak of World War II concerned ways and means of limiting the crop. Representatives from the four great exporters of that period—United States, Canada, Australia, and Argentina—met and talked and talked and talked about international agreements to limit it, but nothing came of them. It is now well known that within our own boundaries the United States Government stepped in and paid people not to grow wheat and several other staple crops—such is the inability of our economic system to handle abundance. Abundance is the devil of the Machine Age in an economy whose operators say they want a free economy and then rush to make limiting agreements if they can.

We have cited this case of the farm as a type result of the coming of machines in the new age. The results have been even more revolutionary in the factory, in transport, and in communication.

The revolutions that machines make possible compel us to re-examine con-



These graphs give some measure of the replacement of human labor by machinery. The third one from the top indicates that Iowa and North Dakota mechanized early, New York and South Carolina mechanized more recently, and California has intensified its agriculture much by growing fruit. The second graph from the bottom may surprise many by the relative acreages in the different states. The bottom graph shows the effect of North Dakota having gone into dairying, California into intensive fruit crops.

tinually the resource bases of our relation to our environment.

4. *The Fundamental Materials of Industry and of Life*

Minerals. The present culture of the West is sometimes spoken of as a "mineral civilization," and quite properly, because we are using them as never before. It is in the field of minerals that we recognize most sharply that the resources of the earth are definitely limited.

Without minerals, our economic life, as at present constituted, would fall to pieces, almost as though struck by an atomic bomb. Most of the crust of the earth is useless to the manufacturers. It is merely common earth or common rock, but here and there the sorting processes of water have sifted out certain sands which become the material for glass and certain gravels join the sand and the stone in being materials for the builder.

Most of the common rock is at best only building stone, but ages ago, deep down beneath the then surface, cosmic force has twisted, broken, soaked, dissolved and deposited material in the form of ores and crystals that we can use.

We are probably in the golden age of metals. You will certainly think so if you will spend a day driving around the roads in the central Rocky Mountains, not far from Denver and Colorado Springs. The number of abandoned holes, old railroads with tracks torn up and carried away, foundations of buildings long since gone, villages in all stages of abandonment, rack and ruin—all these point to a past that is gone to industrial effort that is finished—to resources that were, and now are gone. And it is less than 80 years since the railroad reached this land of metals.

In the United States, we have probably found most of our rich mineral deposits, except perhaps deep-ore deposits. Unfortunately many of the metals have the richest deposits near the surface where water can have done its work in helping to make the deposits. Fortunately this does not seem to be true of petroleum.

The rapid scientific development of new industrial processes has enabled us to use lower and lower grades of ores; and this may continue, but the discussion of copper in another part of this book would suggest that we must have almost reached the limit with this very valuable metal.

The published estimates of our lead, zinc, petroleum, and some other minerals are far from comforting, especially if we will stop for a moment and think in terms of generations or centuries. There is much time yet to come but it is not making metal available very rapidly.

It is quite likely that future generations (not very far in the future) will curse us of this day for the way we have exhausted resources of limited quantity for trivial uses without any regard whatever for the future.[2] Which of us really gives much thought or makes much sacrifice in the interest of our descendants of 2000 or 2100? Unfortunately *we must eat today*. Thus

[2] It is said that a member of the Congress of the United States once exclaimed on the floor of the House, "Who is this posterity? I'm tired of hearing about posterity. What have they ever done for us?"

one of our western states not long ago wasted precious copper to make automobile license tags to help the copper industry of the moment, but certainly not the copper *supply*. Under the pressure of war we found that something like paper makes good license tags.

But a new star has risen in the mineral firmament—seawater. The all-receiving sea contains almost everything that is in the crust of the earth, for example, a cubic mile of seawater is reported to contain about four million tons of the very light and very useful metal, magnesium. A plant on the coast of Texas extracts this element from the waters of the sea. Here we have the first inexhaustible mine. Akin to this magnesium plant on the coast of Texas is a bromine plant on the coast of North Carolina. We have plenty of coasts and plenty of sea—let us watch for the chemists, physicists and engineers to do their miracles with its limitless waters! Perhaps the future generations may bless us, rather than curse, but exhaustion is exhaustion.

Plants! How much we are dependent upon them! Every sprat, every shark, every swordfish, every whale that comes out of the sea, every clam that hides in the mud, is a product of the microscopic plants that live in the waters of the sea. Every bit of protein, fat or carbohydrate we eat to nourish our bodies comes originally from plants.

Now, here comes the chemist, discovering ever new basic economic uses for cellulose, starch, sugar and protein, and plants have the basic patents for these four, and the chemist of today waits upon plants to produce them for him, and he is not very hopeful of his ability to make them for himself. And if he did, he would have to have some other material thing with which to start. Chemists can perform miracles, but they have to start with something. There is a limit even to synthetics.

Now that the plant kingdom, nourisher of all animal life, is also found to have important basic chemical raw materials, it does indeed loom high in importance among the assets of the human race. In spite of this fundamental importance, we really know very little about plants, but the outlook is much rosier than the mineral outlook. As to our knowledge of them, a recent advertisement for a book stated the fact that one man still living had discovered and classified four thousand *new plants* in the southwest Pacific area.

The late Boyce Thompson seems to have been a true prophet when some years ago he concluded that one hundred years from now man would need to know a great deal about plants and left his copper millions to endow the Boyce Thompson Institute for Plant Research, at Yonkers, N. Y.

Great new resources from plants may be expected to result from improvements in three directions: (a) better use of present plants; (b) finding new wild plants; (c) creating new plants and better plants by plant breeding.

A Better Use of Present Economic Plants. A man from the North Central states moved into a locality not far from the shore of the eastern part of the Gulf of Mexico. He lived on the edge of a small town, had a garden and a cow. The cow got sick. He sent for the veterinarian, who said, "Have you been feeding this cow bone meal?"

"No," said the Northerner.

"Well, then, she is going to die. It is

too late to begin now." The point is that the repeated leachings of thousands (millions?) of rainy winters and rainy mers, plus the sortings of running r through several geological proc- , including the waves of the sea, made the so-called soil in this and y other parts of the world little than sand, silicon dioxide, an al- : insoluble substance, almost non- itious, so far as plants are concerned. plants that grew in this sand were are *deficient* in stuff to make bone. refore this cow must be fed bone or else—

e are now discovering that plants grow and look well in soils that are ient in many of the things that a t would like to have and which ld make it much more nutritious imals and men that eat it. In short, science of nutrition, plant and ani- is apparently in its infancy and the tice of plant nutrition has scarcely born. Meanwhile, the commercial d is getting some of its food from ts that grow on soils that are de- nt in things that are vital to us, the s. Our agriculture consists chiefly king things out of the soil and send- them away to market and they do come back.

n article in *The Saturday Evening* , September 1, 1945, entitled, "Are Starving to Death?" refers to one of southern states, where soils were rally low in fertility. The writer, les Rawlings, says the above-men- d farm practice, "makes so serious Rountree report that no less than 100 potential inductees for military ce in this war were rejected on ical grounds, whereas in Colorado, re mineral depletion has been less, 70 out of 100 were accepted. Those Southerners simply were not eating well enough." Which, or how many, of the fourteen vital elements are necessary to be put into our fertilizer mixtures? Herein lies an enormous possibility of expansion of crop area and of crop yield.

As an example of the results from this field of activity, one of the authors of this book, who happens to have a farm;

TABLE 49

(In bushels per acre)

	1880–85	*1907–10*	*1925–29*	*Increases between 1885 and 1910*
Wheat.....	24.54	38.55	39.5	14.01
Rye.......	23.86	36.69	38.4	12.73
Oats.......	49.79	81.48	70.9	31.69
Barley.....	38.25	57.57	50.8	19.32

reports that his alfalfa crop was revolutionized by the application of ten pounds of boron per acre. The use of boron as a fertilizer is rapidly spreading.

The experience of Belgium, where agriculture has probably reached its maximum of intensity in the Western world, shows the possibilities, also the limitations, of artificial fertilizer and good farm practice.

The increase in yields before 1910 compare well with total yields in many countries, but the figures for 1925-29 show that the increase stopped at 1910. The figures for 1935-38 were no better than 1925-29. There is a top to crop yields, unless better strains of plants may yet be found.

Finding New Plants. The potential value of this little-worked mine, the

vegetable kingdom, rises when we think first of a better use of our present crop plants and, second, of what plants now unused might become crop plants if we knew their qualities. The fact is, we probably know but few of the useful qualities of the plant kingdom. The American Indian used many more crop plants than we do, because we have specialized on a few that were best under our present conditions. American agriculture has been enriched by plants introduced from foreign countries in recent years through search of foreign lands by men sent out from Washington. For examples, see Durum Wheat, Soybeans, Sweet Clover, Lespedesa. All of these have been introduced into this country from foreign agricultures within a few recent decades and are making great changes.

This life-size picture of high bush blueberries illustrates the efficacy of plant searching and plant breeding. The late Frederick V. Coville, of the United States Department of Agriculture, got a dozen or so of the best wild plants out of many millions. One of these wildlings is in cultivation. This one is produced by crossing two fine wildlings, and a new industry is rapidly spreading over the North Atlantic coastal plain.

The domestication of new plants is an entirely different but allied field of activity. Vast additions to wealth, comfort, and industry are to come from the domestication of plants now unused or only produced by unaided nature. We cite one case. For two centuries cinchona bark for quinine manufacture was gathered from trees growing wild in the forest, and no one thought of questioning that the east slopes of the Andes had a permanent world monopoly of this precious product until in 1852 the Dutch Government introduced it into Java, and in 1860 the English introduced it into India and Ceylon. The cinchona plantations of the East Indies, with their populous valleys and humid mountain slopes, captured the market and in a few decades gave the world quinine at one thirtieth the old price. The export from South America practically ceased, for the hunter in the sparsely peopled forests is unable to compete with the myriad villagers and the systematic plantations of Java. The quinine famine of World War II started

forest hunting again, planters to planting in tropic America, and also set the chemists to work, and they have apparently found a laboratory substitute.

We need only refer to the domestication of the rubber tree as possibly the first of hundreds yet to come.

The implications of this philosophy suggest a vast work—the careful survey of the world's plants both tame and wild, and a careful consideration of their usefulness. Such work, requiring many generations of time, can give great increase of food and industrial materials.

The problem of plant breeding and some of its processes are indicated by the three generations of wheat in this photograph. At the top, two varieties, one smooth, one bearded, are crossed. At the right, B is female parent. The three small heads, A′, A″, and A‴, are selected from the offspring of this cross. C_1, C_2; D_1, D_2; E_1, E_2; etc., are offspring of these second-generation plants, and stand at the right of their parents.

At the left, the process is the same except that the bearded head, b, is the female parent, a difference which is sometimes very important in plant breeding.

Since one head of wheat may have two or three dozen grains, the A′, A″ row might have gone to 24 or more, and in the third and fourth generations, the possible number of plants from which to choose begins to be appalling, but it gives the breeder great opportunity for selection.

Plant Breeding—Creating New Plants. Plant breeding consists in taking the pollen of one plant and using it to fertilize a plant (perhaps of another species) having different qualities and thus getting a new kind of plant.

What will be the useful qualities that the science of genetics can bring out of all of the thousands of species and their other thousands of useful hybrids—when we make them? We have made a small start at finding this out—a very, very small start. It might almost be called microscopic when one considers its theoretic possibilities.

The science of genetics is slower than the chemical laboratory in experimental and developmental processes, but its potentialities are stupendous. The breeding of animals and plants only got out from under rule of thumb and careful guesswork in the year 1902, with the publication of Mendel's Law. This law might be called the science of heredity. Thirty-five years later, the United States Department of Agriculture published its 1937 Yearbook, devoting more than 1,300 pages to the then achievements in breeding better plants and animals.

We have just talked about the new plant feeding that will give more crops per acre and more acres for crops by bringing into productivity soils that are naturally low in plant food. Now consider the science of genetics! It is already enabling a hen to double her number of eggs per year, therefore double the number of eggs per hen's nest, per hen house, and per hen-year-care. In addition to that she will in her lifetime give more eggs per unit of feed.

Thus the greater crop yields per acre can now be fed more scientifically to the scientifically bred pig, and will give us more sausage per unit of feed.

All the health experts are making much proper clamor about more milk to build bone and tissue and bring vitamins. Now farmers who are breeding cattle with the aid of cow-testing associations and cattle-breeding associations are making the cow give twice as much milk, therefore twice as much milk per cowbarn and per cow-year-care. Also, by proper selection of ancestors, more cream per gallon of milk, more milk per unit of feed.

However, it is in the plant kingdom that we see the more astonishing miracles that come from the application of genetics.

In the realm of field crops, we will limit ourselves to one example—hybrid seed corn. One specialist farmer now spends years developing two pure strains of corn which, when brought together, produce a hybrid. Now, it is one of the strange things that a hybrid plant may often have characteristics that were apparent in neither ancestor. For example, greater size, greater yield, greater number of progeny, greater hardness, earlier ripening, etc. In the case of hybrid seed corn, it makes several more bushels on a given acre, with given care, than any other known kind of corn—hundreds of millions of bushels of corn more per year in the state of Iowa alone, for the same land and the same labor.

In the few short years that man has known something about the science of genetics, he has made good progress with many of the herbaceous crops of the present agriculture, most of which are annuals. Being annuals they give quick results to breeding experiment,

but the trees are the real engines of botanic production.

The essential thing about the earth from the agricultural standpoint is its fertility. How to unlock it is man's problem. The key for this unlocking is vegetation, and to get fertility vegetation must have as aids, first, heat; second, light; and third, moisture. Therefore, in the past it has been the warm moist places that have produced man's food, and in addition agriculture has thus far done but little where the land could not be plowed. The past insistence on this fourth factor (arability) has caused vast possibilities of fertility, heat, and moisture to be practically unused, and vast soil resources to be barbarously wasted and destroyed through erosion to the permanent and profound injury of the earth as the home of man. The barriers that have held men from utilizing fertility have been, first, cold; second, aridity; third, steep and rocky surface; fourth, excess of moisture; and fifth, unwholesome climate.

Down to the end of the eighteenth century, man's progress in the increase of powers and the combat of difficulties was essentially the result of the unscientific effort of untrained workers and the enthusiasm of the individuals who tamed the wild animals of the forest, cultivated and improved by selection those plants that seemed most useful, and, by accident,[3] made inventions and discoveries. We have now entered upon a new epoch, in which governments and private institutions as well as individuals are promoting science and its applications.

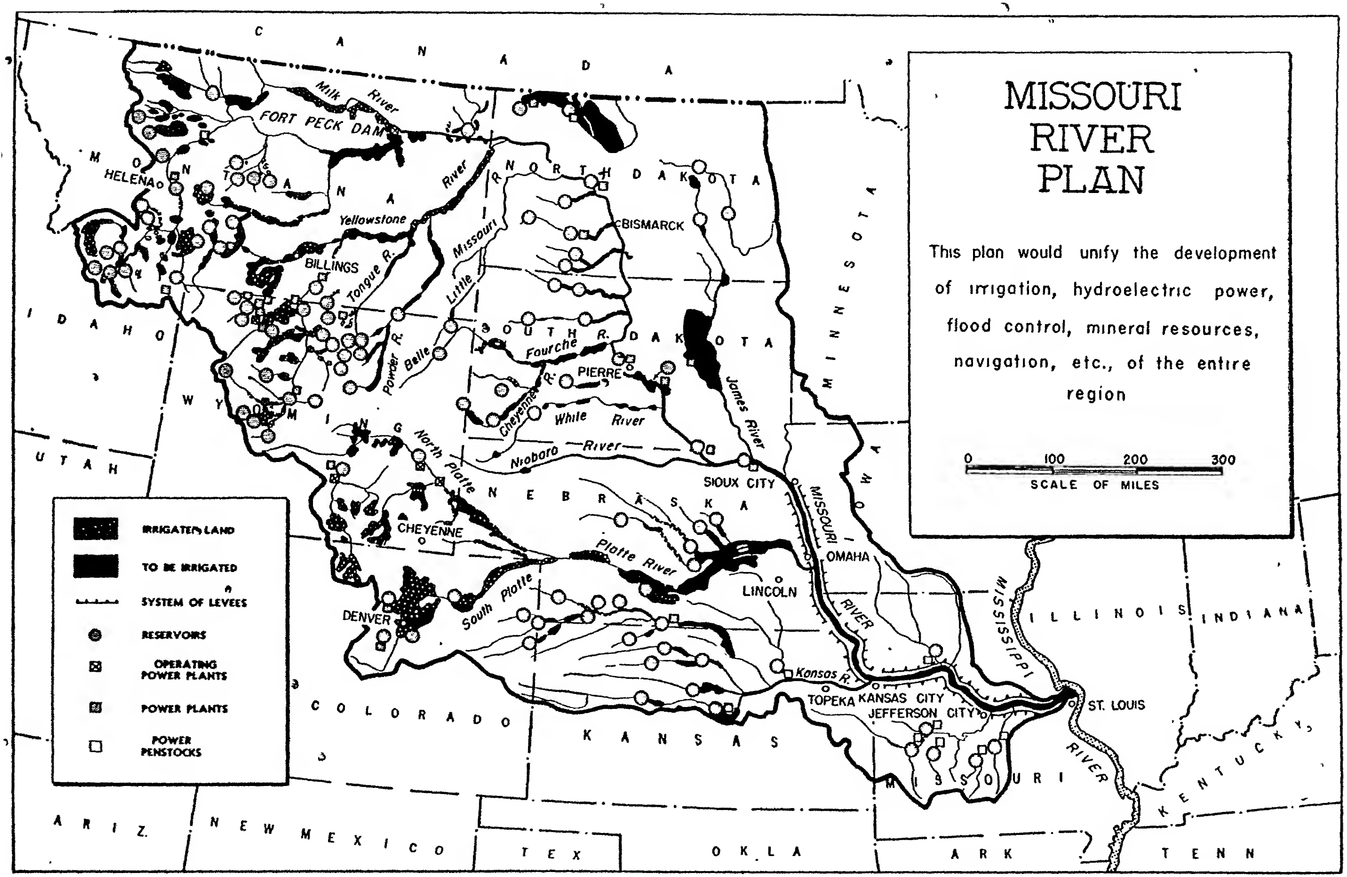
New Resources Through Tree Crops. Possibly the greatest of all agricultural benefits will come through the utilization of crop-yielding trees and the breeding of new ones—a piece of scientific work for which we are now ready.

Man began agriculture at the wrong end of the plant kingdom. The grains upon which we feed are all weaklings. Harvest is often but a small handful in comparison to yields of tree crops—the engines of nature which have for ages been giving man the most astonishing object lessons of production, and inviting him to improve them rather than the feeble grains at their feet; but the grains are annuals—a profound advantage to the primitive man (probably woman) who started our agriculture.

Great Productivity and Profit of Tree Crops. The chestnut orchards of France, Italy, and Corsica yield *per acre* nuts in amount approximately equal to the per acre of wheat fields in the United States. The wheat grows on the best, most nearly level, and most easily tillable soil of America, while the chestnut orchards often occupy the steep, rocky, untillable mountain sides.[4] While the wheat lands

[3] The first great invention in cloth making that led to the Industrial Revolution was made by a minister whose attention was called to the awkwardness of hand tools. The cotton gin, that most revolutionizing invention, *happened* because a Yankee schoolteacher, sojourning in South Carolina, *happened* to have his original mind called to the problem of seeding cotton; many other similar stories might be noted. But the technical nature of present industry has removed revolutionary changes from the chance visitor to the man who had been educated and trained, without the too usual accompaniment of having his mind shackled by what is and what the old man says.

[4] The value of these orchards is most evident. In crossing the Apennines from Bologna to Florence, the first 2,000 feet of the climb upward from the level plain of the Po is through an unproductive and almost unpopulated district. At 2,000 feet the forest line begins, groves of grafted chestnut trees cover the rugged hills for many miles, and numerous villages show that these groves support a large population.



This map records some realities and many hopes. It is inspired by the success of TVA. The 105 proposed reservoirs will, when completed, increase irrigible land water power, give some flood control, assist navigation and greatly increase the possible population of this area. The creation of the Missouri Valley Authority is now under earnest consideration.

must be plowed for each crop, the chestnut orchards produce their crop without tillage. The trees stand among the rocks and at their feet are pasturage and herds instead of the laborious plowing and seed-time of wheat culture. This tree crop is the bread supply, pig feed, horse feed, and the money crop of many thousands of mountain dwellers in the higher regions of Mediterranean countries.

Despite this productivity of trees, we have until the present depended almost purely upon chance to produce the fruitful strains. Freak trees have arisen by accidental hybridizing here and there to become the parents of a variety—Baldwin apple, navel orange, etc.

Now that science has caught up, we need no longer depend upon chance, the well-tried method of the ancient nomad. Plant breeding will enable us to harness the trees, the great productive engines of the plant kingdom, and as a result tree crops, the crops of great yield, are to come out of the corners where they now occupy so inconspicuous a place. It is probable that the cultivated fruiting trees of all sorts in the United States do not cover over 2% as much ground as is given over to the less productive grains. As agriculture adjusts itself suitably to resources, the area of tree crops, with their great superiorities, may eventually outstrip the grain crops. It is almost certainly true that an orchard of selected oak trees will yield in acorns more carbohydrate food, for man [5] or beast, per decade than corn can be made to yield on similar land in much of the hilly land outside of the American Corn Belt. But the idea seems like a joke to most farmers. After all the human mind is wonderfully sealed against new ideas. "All those in a position to know—"

Already many crop-yielding trees have rare specimens that are good enough to be made into crops without any plant breeding at all. Among these may be mentioned the pecan, shagbark, hazel, black walnut, English (Persian) walnut, persimmon, mulberry, sugar maple, pawpaw, and above all the oaks—so important today in Spain and Portugal.

What New England and all hill countries need more than any other thing in the whole list of relations between man and nature is an application of science to give them an agriculture that is ad-

[5] Anyone who thinks that bread from acorns sounds fantastic should remember three things: (1) that bread is merely a carbohydrate food, (2) that whole peoples have lived on acorn bread for unknown centuries—the Missouri Botanical Garden has made good bread from common acorns which yield their bitterness when grated and given a water bath, and (3) there are hundreds of millions of people who do not eat bread, certainly not cereal bread, but that is no sign that they are savage, barbarian, or even heathen. They get carbohydrate and protein, but the climate in which they live helps man to produce them most easily in other forms. One evidence of tropic riches is the great abundance of starch-producing plants that are bread substitutes. Throughout the length and breadth of the damper part of the tropics several easily grown plants afford foods which are the essential equivalent of the bread so dearly beloved by the Western world that two thousand years ago it got its place in the most widely used prayer in Christendom.

Cassava, one of the tropic bread substitutes, helps to fill the local need in many lands. Like the sweet potato, cassava is grown for its starch-producing roots. The native grates and dries it, making of it not only a nutritive equivalent of bread, but actually a piece of bread, although it is not the light bread to which the northern world is accustomed, but a thin, stiff cake, rather insipid to the wheat-eating palate. That, however, is a matter of habit. Here is a fact of great significance. *We like what we eat.*

In many tropical lands, cassava cakes and boiled or baked cassava roots are standard articles of diet for the natives, partially taking the place of the corn bread of the American Negro, the boiled potatoes and rye bread of the European peasant, and all the other breadstuffs of the temperate zone.

justed to their unplowable soils. The present agriculture of New England is an imported misfit from the lands suited to the plow.

The uses of land run through grades of intensity in utilization and value of output somewhat as follows: First, the forest with its game, furs, and gums; second, the forest with its lumber; third, pasturage; fourth, tillage and grain; fifth, tree crops. Whenever we find agriculture going over from the annual grains to the perennial tree crops, we find an agriculture of increased output and increased value, rivaled only by the market garden. Wheat, corn, and oats yield but poorly in comparison to the heavy harvest and large income furnished by the apple,[6] peach, orange, date, olive, or Persian (so-called English) walnut.

The plant breeder, the constructive botanist, now tells us, for example, that it is only a matter of time and patience to make, by repeated crosses, a good crop-yielding hickory tree, almost an ideal hickory tree. It can have the delicious sweet flavor of the shagbark, the thin shell of the bitter nut, and enough of the size of the giant Missouri shellbark to put it in the English walnut class so far as food value, accessibility, and desirability are concerned, but with one great difference from the standpoint of production. It is thoroughly acclimated by thousands of years' adjustment to our changeable climate, and the English walnut is a Mediterranean exotic, thoroughly at home in the United States only on the Pacific coast where Mediterranean conditions prevail.

For two centuries the white man has been felling the forests of America to make fields. Many an eastern field, now of low fertility and scanty harvest, or perhaps ruined by gullies, has, or has had, upon it the acorn-bearing oak, the nut-bearing walnut, chestnut, and hickory (or pecan), the seedling apple, the seedling peach, the redheart and blackheart cherry (wild mazzard) and the fruitful persimmon and pawpaw, or the sugar-yielding honey locust. Yet year by year for generations, all these astounding possibilities of crops have been negligently brushed aside, cut down, rolled in piles, burned up to make room for wheat, corn and tobacco—and gullies.

Science, backed by money and patience, promises some good tree crop for a million square miles of American hills. But science is as yet doing little to bestow this precious gift upon us, because the work depends upon appropriations by far-seeing legislators—or benefactors like Boyce Thompson.

Trees do not depend upon the plow. They laugh at rocks. They can wedge their trunks in between the rocks, send their roots far down into the moist subsoil, rear their heads into the abundant sunshine, and *produce*. What care they for rocks? If there is earth among them, the tree roots will find it. If the rocks encumber the surface they merely serve as a mulch to keep in the moisture.

Everywhere east of the Mississippi trees will grow where there is earth standing above the water level. With the properly improved varieties of tree crops there is no reason why Massachusetts might not, square mile for square

[6] U. S. Senator Harry Byrd, of Virginia, reports that some of his York Imperial apple trees yield 100 bushels per tree every other year—20 trees to the acre, and many acres that yield 1,000 bushels.

mile, produce as much food as Kansas does now with her grain fields, and her fat cattle, fat pigs or fat sheep or fat turkeys—possibly more. The proper succession of fruiting mulberries, persimmons, chestnuts, walnuts, pecans, hickories, shagbars, filberts, and many other tree crops that might be introduced from this and other lands would give us an abundance of good food or one continuous succession of workless harvests to which the pigs, sheep, and turkeys could walk and eat if man himself did not want them.

Thus may the eastern country double or more than double its possible production along the now existing lines. The two-thirds that is now too hilly for good cultivation can, with tree crops, double and more than double its present meager output. Even the roughest third, now hopeless of tillage, can with tree crops match in productivity the best third which should remain for the agriculture of the plow, to which it is by nature adjusted.

The benefits that tree crops can render the arid and semi-arid[7] land may be equal to those that may be conferred upon the hilly lands. The grasses, grains, and ordinary forage plants are ill equipped to fight for life against the rigors and uncertainty of aridity. Corn, for example, must have water within a certain two weeks or it is blasted, but the trees can prepare for siege. In the first place, their roots can go down from 30 to 60 feet. These roots can store up energy, and when the time comes they can make fruit. Further than this, many of the trees of the arid lands are legumes with the legume's power of gathering nitrogen from the air, leaving a part of it upon their roots to enrich the soil, and using the rest to make seeds that are rich in nitrogen and, therefore, meat substitutes and tissue builders.

A claimant for superiority in the possible harvest of arid lands is the wide-pod honey locust, a leguminous tree with a big pod easily picked up and full of rich beans. Its seed and sugary pod combine to make one of the richest of all stock foods, being high in protein and often analyzing over 50% of sugars and starches. It nearly duplicates in quality the carob bean, the "locusts" of John the Baptist's desert sojourn. This leguminous tree is now a crop grown in all Mediterranean countries, and the beans are largely exported from Cyprus to England for stock food. In Spain it was the oats of the cavalry horse when they had cavalry.

This honey locust is but one of nature's many desert possibilities. One of the botanists of the Department of Agriculture has found six species of woolly fruited wild almonds growing on the desolate shores of Pyramid Lake in the so-called Nevada Desert. These six varieties bear nutritious though small and bitter fruit. Mr. Frank Meyer, Plant Explorer of the Department of Agriculture, brought back from central Asia the seeds of wild almonds producing good fruit and good edible oil in a climate with an estimated rainfall of 8 inches per year. The desert may yet bloom with almonds.

Foreign lands certainly have great numbers of promising trees to offer us when once we set out in earnest to breed up tree crops. If we will, it seems that

[7] See J. Russell Smith, "The Real Dry Farmer," *Harper's Monthly Magazine*, May, 1914, and *Tree Crops*, 1929.

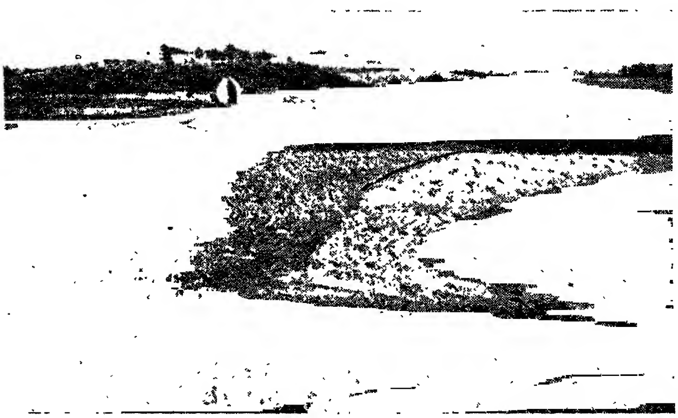
we may easily breed the crop-yielding trees and convert tens of thousands of square miles of almost vacant western range into fruitful orchards for the fattening of beasts or the feeding of men.

One of the best examples of a new tree crop is the Hawaiian experience with the algaroba, a species of the mesquite, many species of which will grow in considerable areas of the United States. Hawaii has, after many difficulties of a mechanical nature, learned to grind up the beans and pods of the algaroba bean, and thereby added an industry of great promise. The meal resulting from this grinding is worth about as much as bran for stock food, and is the "mainstay" of the dairy industry of the Islands. The Hawaii Experiment Station states that an algaroba forest yields four tons of the beans to the acre per year, and one ton of wood. That puts to shame 50 bushels of corn (2,800 lbs.) and its supporting fodder. The labor of production consists of picking up the big beans, which grow upon a leguminous tree introduced about the middle of the last century from Peru or California. The Hawaiian algaroba grows on the "waste" land—rough, untillable and often with a rainfall too low for tilled crops if they could be there.

The tree-crop possibilities of the fecund tropics are beyond description here, but it should be remembered that most tropic products are already tree crops—tea, coffee, cacao, rubber, coconut, oil palm (fruit and nut), Brazil nut, allspice, nutmeg, cloves, cinnamon, cinchona, orange, mango, avocado, grapefruit. The crop trees are particularly valuable to the tropics because many tropic lands have irregular rainfall, making it difficult to know when to plant a grain crop. The permanently established tree is *there* ready to use the rain when it comes. We have thus far used but a small fraction of the possible crop trees of the tropics, and many of those we have used have not been used commercially.

5. *After Man the Desert*

The proper development of tree crops as indicated here can effect the greatest saving in the world conservation movement—the conservation of the soil, our greatest and irreplaceable resource. The Theodore Roosevelt Country Life Commission uttered this warning thirty years ago: "A condition calling for serious comment is the lessening productiveness of the land. Our farming has been largely exploitational, consisting of mining the virgin fertility. On the better lands, this system of exploitation may last for two generations without results pernicious to society, but on the poorer lands the limit of satisfactory living conditions may be reached in less than one generation." The more recent findings of the United States Soil Conservation Service put appalling concrete proof back of this statement. The saying, "After man the desert" is much too true, as the frightful desolation of most ancient empires attests. It has nearly all come through erosion, and tree crops with their earth-gripping roots can practically stop it all, for the tree is nature's method of holding earth on the rocky framework which erosion reveals so near the surface of most of our hills and mountains. It is pathetic to think how helpless are *civilization* and the *race* in the face of the individual's desire to seek



This hillside may have a future if succeeding generations continue the strip crop, horizontal row system. Gullies do not have room to start in these narrow strips.

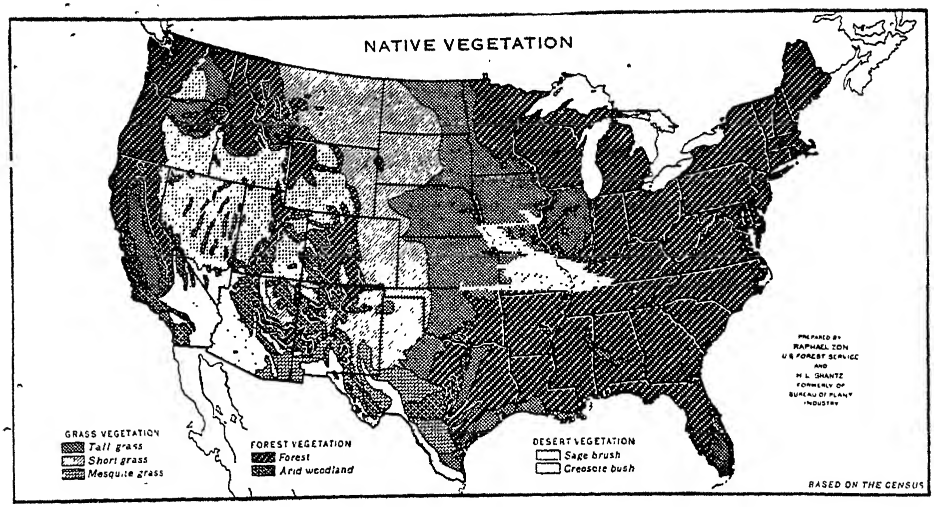
today's gain by wasting something that will stay wasted for a million years.

The Ultimate Uses of the Land. The final uses of land to get maximum return with conservation of the soil seem to be about as follows:

1. Where heat, moisture, and fertility abound,
   a. level or gently rolling lands will be tilled as at present but planted to more productive varieties of plants; and
   b. hilly, steep, and stony lands will be put to tree crops;
   c. if too wet, it can be drained and put to intensive plow agriculture.
2. Lands that we now call arid or semi-arid can in many cases also be used for tree crops and other varieties of dry farming, especially tree crops in gulches. A small percentage can be irrigated.
3. Cold lands where the cost of keeping warm is great or where frost interferes with crop production will be left to produce our timber-yielding forests.
4. Beyond the tree crop and forest zones will come deserts of bush and bunch grass and moss-covered tundra to be used as open pasture ranges by animals suited to the conditions.
5. Very steep and rocky land may be terraced, tree cropped, or forested. There is no sense in letting fertility that is available to trees remain unused in lands that have a climate that is good for human beings.
6. The bare desert, the bare rock, and the snow will then as now remain without harvest other than
   a. possible minerals where the earth is visible, and
   b. possible utilization of deserts for sun-power generators,
   c. snow field water storage.

6. *The Tools Are at Hand, Can We Use Them?*

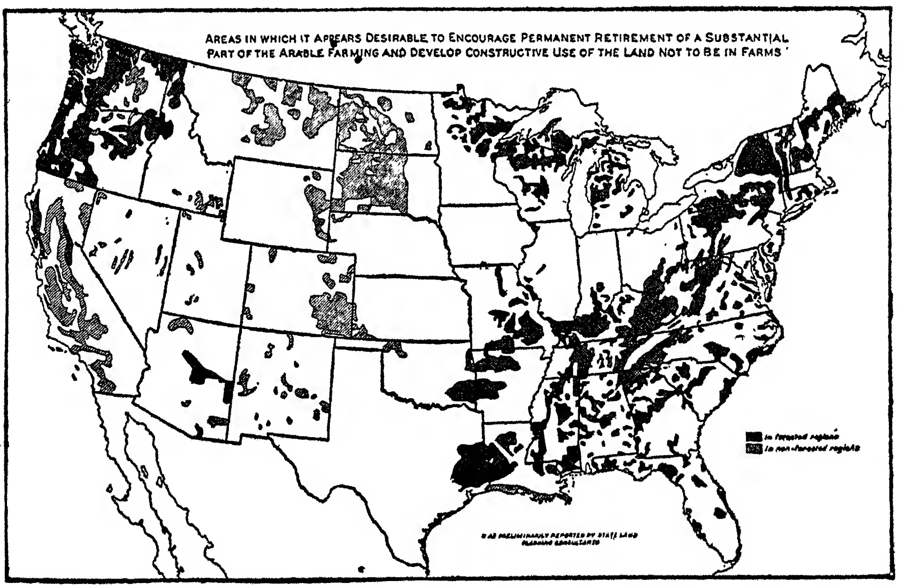
In the previous pages we attempted to give a peep into some of the vistas of new resources and new industries that advancing science has made possible. Unfortunately there are deterring factors to which some heed should be given at this time.



A

The map of native vegetation is one of the very important maps. This one shows that nearly all of the United States east of the Mississippi River is naturally forest land. But for the Indians' grass fires on the prairies, there would have been more natural forest. Give them a chance and trees will grow in all of Iowa and beyond.

A large proportion of the natural tree land is too steep for plow agriculture, but has climate and soil well suited for the tree crop agriculture, a great resource for a future if the need for more produce arises and the soil has not already been destroyed.



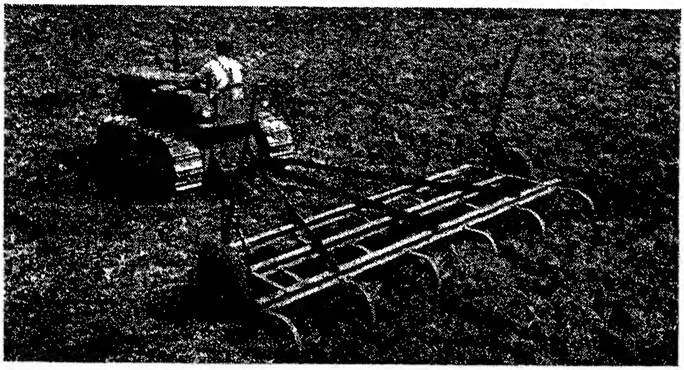
B

This map is almost stupefying. By it the National Resources Committee recommends permanent retirement of a substantial part of the cultivated land over areas of appalling extent. Much of this land can be cultivated by the use of strip-crop terracing. Much more of it is now eligible for the new grass economy, see next figure.

Exhaustion of Minerals. Perhaps we can find substitutes, perhaps not, but the fury with which we dig up irreplaceable metal and the trivial "uses" by which we waste it might suggest to the Man-in-the-Moon that resource exhaustion was one of our great social objectives.

Soil Destruction. The United States Soil Conservation Service has published a terrifying map (page 377—Soil Erosion Map). If we should keep on destroying farmland through wind and water erosion for a couple of centuries at the rate we have done it for the past half century, the United States will find itself agriculturally somewhat in the class of Italy, unless our population also shrinks.[8]

We transplanted European agriculture along with our families, our crops;



Here is the mechanical basis of an agricultural revolution of great importance to our future, if we are going to have one. From eastern Maine to the Golden Gate, the usual system of getting a piece of land into grass is to plow it up and grow corn, or some other crop, mostly corn, if corn will grow at all. This lets the land wash and if it is sloping, and most of the land is sloping or steep, a corn crop lets it wash terribly. In the spring of 1945, we saw this machine tearing the sod to pieces on steep eastern hillsides, where one thunder shower might cut gashes six inches deep if it had been planted to corn. This tearing of the sod to pieces was followed by the disk, which chopped it. By two or three diskings, it was chopped and kneaded into a mass of earth held together by threads of grass sod and roots. It was immediately limed, fertilized, and seeded to a mixture of grass and oats. In a few weeks it was a mat of vegetation. Heavy rains were absorbed and the soil held against erosion by the spongy mass of grass and roots distributed through the topsoil.

By June 1, the root mat of new growth was complete and there had been no erosion despite heavy spring rains. If the land is not left in permanent pasture, this process can be repeated from time to time for reseedings, with almost no soil loss. Grass silage and hay complete the basis for a livestock economy.

[8] The very day that this paragraph was written, we received a letter from a colleague in Ohio, from which we quote:

"At present I am making an effort to find some method of saving the wasting counties of Southern Ohio. I am taking an actual inventory of the financial income of the so-called farmers of this depleted area. I find that most all of them have some industrial income not only to supplement their farm income, but to finance their farms. It is only a matter of time until everything 'goes down the river!'

"I feel that somewhere there must be an answer to the plight of these men. None of them are able to—or they cannot see the tangible return of plain lumberwood trees."

It is scarcely an exaggeration to say that soil conservation has not yet got to the *bad* hills, of

and our domestic animals, but we did not transplant the European soil saving processes. European agriculture is an agriculture of close-standing plants, wheat, oats, rye, barley, clovers and grass. These plants stand close together,

It is hard to believe, but the hillside beyond this log structure at the head of John Creek in Cocke County, Tennessee, was cleared for corn and they did not clear it in strips, they cleared the whole hillside. Investigation has shown that such hillsides are ruined in from five to fifteen years. In the United States of America, the ownership of land is the license to kill.

are not intertilled, and hold the ground against erosion. Only small patches of good level, European land are put to the tilled crops, chiefly beets and potatoes, which make up only a small percentage of European crop acreage.

America furnishes three soil-destroying crops, three deadly enemies of the future—corn,[9] cotton, and tobacco. These plants grow in rows, the cultivator runs to and fro between the rows, loosening the soil, making it ready to be washed away. Then comes factor No. 2, the thunder storm, so uncommon in Europe and so common over most of the plowed part of the United States. The Soil Conservation Service is doing wonders, but these wonders must be greatly extended and permanently continued if the United States is to approach becoming a permanent country. It is highly significant that Oklahoma is one of the worst eroded parts of the United States. It was only taken away from the Indian in 1890 and 1892, and given away as homestead, and land abandonment was well under way by 1910. By 1930 we had a national problem, "Okies" and "Arkies," landless families, homeless wanderers, seeking a day's work.[10] This time the veteran land destroyers of the Cotton Belt discovered that they could not destroy one farm and go west and find another waiting for them. We had come to the end of an epoch—the end of good free land.

To tell just why the children of the Oklahoma homesteaders became Okies, we quote a memorandum prepared in 1945 by the United States Soil Conservation Service.

Erosion Damage in Oklahoma. Soil erosion is the No. 1 problem of Oklahoma agriculture.

Surveys by the Soil Conservation Service show that erosion has damaged 85 of every 100 acres on the farms and ranches of the

which millions are being destroyed at the hands of men with the plow complex—plowman's folly. The Swiss have a *grass economy*, and their hills remain. Billions of billions of grass roots anchor the earth and hold it tight on Switzerland's rocky frame.

[9] What happened to the men who developed the culture that left such astounding remains on the limestone plains of Yucatan? One student says they grew corn and the fields washed away. Exit Yucatan!

[10] See opening chapter of *North America* by J. Russell Smith and M. Ogden Phillips, New York, 1942.

The gullied landscape was once a good field. The abandoned house was once a home. The hill need not have been ruined, the house need not have been abandoned. We wonder if the inhabitants ever sang, "America," and knew what they were singing. —"I love thy rocks and rills—"

state, with the damage ranging from slight to the loss of all the topsoil. Of 34,803,000 acres in farms and ranches, 8,543,000 acres have lost more than three-fourths of the topsoil through erosion by wind and water, 13,460,000 acres have lost between 25 and 75 per cent of the topsoil, and 6,222,000 acres have lost some topsoil but less than one-fourth of it.

Why are these calculations of damage given in terms of topsoil lost?

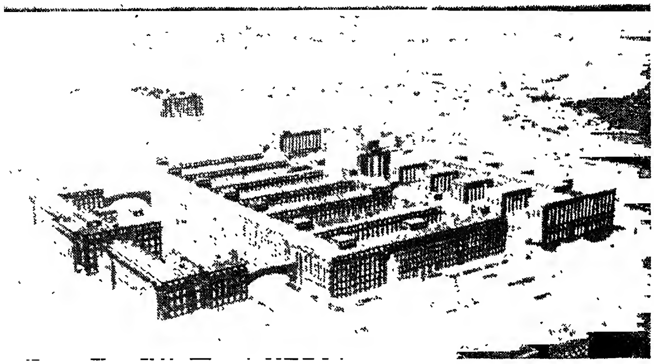
Topsoil is priceless. Nature requires 300 to 1,000 years to build one inch of it. Yet one heavy rain falling on a steep, freshly-plowed unprotected field may remove from the entire field as much as one inch of soil and from smaller areas the whole layer may be carried away.

Man depends on the topsoil for the production of his food, clothing, and much of his shelter. The highest concentration of soluble nutrients, ready for use by plants, is found there. It contains the highest percentage of organic matter and the densest population of simple forms of life that live in the soil and contribute directly or indirectly to it productivity. The loss by a field of any portion of the topsoil directly reduces the ability of that field to produce. The remaining soil is more susceptible to continued erosion.

Japan is supporting its millions on about 15 million acres of cropped land. Said a Japanese gentleman as he looked at some American gullies, "No one loves this land."

A lot of thoughtless hypocrits have stood up and sung, "I love thy rocks and rills," and then kept on destroying the land.

Scarcity Economics. For unknown centuries, the Europeans have struggled against scarcity with occasional famine. Now the new science has solved the problem of production for the Western world. We, of the West, may have a half century of abundance if we use the new science, but can we use it? In this respect, we are greatly like the old woman and the burglar. Every night she looked under the bed for a burglar and at last, after forty years of search,



One of the world's finest insane asylums—the Department of Agriculture at Washington. We do not refer to persons, but to the system they operate, and they did not make the system. Operations in this magnificent building are a flower of scarcity economics—a full-blown blossom of our industrial system in the power age, working through government. Five wings of this building are devoted to telling us forty ways (more or less) to produce more scientifically, more abundantly. For years the bureaucrats in the sixth wing sent out checks to the farmers, millions of dollars of real money to pay the farmers not to produce—and in the midst of it the drafting of an Army revealed a nationwide malnutrition.

We, the producers in the U. S. A., made this artificial scarcity by Congressional law, but we had not the stomach to tax ourselves to foot the bill. For years we borrowed the money to pay for this strange luxury. Posterity may have the privilege of paying, but will they accept that peculiar legacy? Would you pay the debts created by an insane grandfather? It is no wonder that our industrial system is in a state of flux and ferment. It is like our foreign relations of 1946—it has no policy that is backed up by a philosophy, and implemented by a consistent plan.

she found him. What should she do with him? She had never thought about that, and the successful result of her search was consternation.

The somewhat similar predicament of ourselves with our new abundance is revealed by two facts: first, one man reported a personal income of fifteen million dollars a year in the dull 'thirties. He was the head of one of the tightest trusts in America. It could control production, output and price. The managers of that enterprise kept us hungry for a product, and we paid to the head of it fifteen million dollars for keeping us hungry.

At the same time, the unrestrained production of wheat brought such an abundance that the price went down below the cost of production for almost all producers, mortgages were foreclosed, and farmers by thousands lost their farms. They gave us abundance, and we punished them.

Compare those two social payments with your definition of insanity.

Value depends upon relative scarcity. One of the authors of this book owns a farm with a hill of rock, a million tons. He cannot sell any—all the neighbors also have stone. Value depends upon scarcity, and with the new powers of production scarcity becomes harder and harder to maintain, and thus maintain-

ing it becomes one of the greatest objectives of almost every class of producers in the United States. Watch the papers and you can find dozens of examples of it in any month—tariff, trust, patent, price agreement, "Institute," labor union regulation, United States Government paying farmers *not* to produce.

As we go into 1946, our economic system is still under the oxygen tent of government borrowing, which began in the late years of Herbert Hoover's administration. When will it stop? Can it?

Human Numbers and Human Qualities. The *Statesman's Year-Book* for 1944 gives the following appalling facts about the population of India.

TABLE 50

Population of India

		Increase previous decade	
		Per cent	*Population*
1921	305,693,000	+0.9	2,680,000
1931	338,119,000	+10.6	32,426,000
1941	388,998,000	+15.0	50,879,000
Increase in 20 years			83,305,000

In 1926 we attended a Boy Scout function and a Baby Show in a village in Southern India, where the local white representatives of that imperialist lady, the wife of the Viceroy, were doing their bit in carrying out her ladyship's nationwide campaign to "save the village baby." They seem to have succeeded. Knowing something of India's record of famine for many centuries, we asked ourselves at the time, "Save him, for what?"

Most tropical populations have for ages had a high birth rate with the population kept in check by war, famine, pestilence, and preventable disease, all terrible to contemplate, but the greatest of these was preventable disease.[11] Now sanitation and scientific medicine are checking these preventable diseases and we see the populations fairly exploding with numbers.

Java gives us a shining example. The West Indies afford many. One of the most tragic, perhaps, is Puerto Rico, but little Barbados has more than 1,000 people per square mile and they've been migrating for decades. In many tropic areas the coming of a child bears no relation to family capacity to nourish.

What will happen to these swarming hordes of India? Migration? Malnutrition? Sweatshop wages and sweatshop products trying to get into the foreign markets over tariff walls? Unorganized hunger means disease. Organized hunger has meant war in the past—B.A. (before Atomic Bombs). See "Lebensraum" in Germany and Japan.

For centuries the Japanese had a static population, kept so in part by extremely rigorous preventive measures. In recent decades the militarists started to urge increase of population to have the basis for military expansion and conquest. They got the increase and now the enlarged population is forced back into the homeland—a situation set for malnutrition and an explosive psychology.

On the other side of the population problem are opposite conditions, per-

[11] Infanticide should not be forgotten. What millions has it claimed!

This gracious figure, drawn by Homer C. Davenport about the year 1900 to represent the trusts, is the nearly perfect representation of man equipped by the newest science which for years has been advancing the technique of tyranny. The atomic bomb is merely the latest in a series of inventions and discoveries that have advanced this technique much too swiftly.

The almost headless beast above also illustrates Jan Lindberg's words: "The kingdom of the outside has grown faster than the kingdom of the inside." In two millennia there have been few if any improvements made in the Sermon on the Mount, but the sword and spear and crucifying nails of Herod's day have been replaced by such new instruments of destruction as the submarine, the machine gun, the airplane, the block buster, radar, the rocket bomb, the atomic bomb, and the nazi gas chambers for mass murder. All these are new, very new, creations of science.

haps equally alarming. It is widely reported that in the American city populations, in the present period 100 adults are producing about 70 children. At that rate, the generations will be as follows: 100, 70, 49, 34, 24, 17, 12, etc. If five-sixths of the families that move to town become extinct in five generations the question appears to be, not can American civilization maintain itself, but how long will it be able to maintain itself?

7. *The Dictators and the Smashers*

The atomic bomb gives us an entirely new basis for the survey of the world. It should cause us all to take time out to contemplate the worst of man's passions—the lust for power.

The power lust is unique among man's desires. The gratification of the desire for food, drink, sex, the pleasures of the chase, of workmanship, of the intellect, of creative art—the exercise of all these leads to satiety and sleep. But in terrible contrast, the lust for power grows by gratification. It runs away with the human spirit. At times it unbalances the mind. The Romans, with the pitiful record of emperors before them, had a word for it—"Imperial Madness." Power corrupts.

History furnishes abundant illustrations. To read *Mein Kampf* and contemplate the actions of the nazis proves the present and continuing menace of unchecked power. Our victory in World War II has killed no passion, abolished no philosophy—and it has hatched a new crop of hates. The dangerous thing is that the power lust is born in all individuals. It is even shared by some of the quadrupeds.

Grant the successful gratification of the power lust, i.e., getting absolute power, and sadism, torture of other human beings, comes next. The record of the torture chambers of the victorious Germans and the victorious Japanese seems to prove that point.

The machine age and the power age have combined to give us great material comfort, a great interdependence through a great dependence on many persons. We have become completely dependent on continuous transportation when, within a week or a month our food is produced in Colorado or Dakota, processed in Minneapolis or St. Louis, rushed by express trains to eastern cities, hustled from commission man to wholesaler to retailer and thence to our doors. We are fed through this chain of continuously cooperating services and we starve if one link in that chain is broken.

The tugboat men of New York harbor went on strike early in 1946, and within a week hunger threatened Manhattan because of the simple fact that most of its food and coal are brought to the periphery of that island in car-float ferry boats.

Now the desire for power and dominion is deep-set in all of us and the twentieth-century version of "the public be damned" (railroad magnate, 1882) is that, we the men of this corporation will fight it out with this labor union, or we the leaders of this labor union will fight it out with these employers, no matter who goes hungry, cold, half clothed, unemployed, or unequipped. We with this monopoly will charge what the traffic will bear.

The extreme form of this attitude is rule or ruin. It should not be forgotten that in the days of his defeat, Hitler, who after all was a human being (sad to confess), did all he could to wreck the Germany of which he had been the revered leader. He made a pretty thorough job of it, too. The psychology of the wrecker has not received its proper share of attention by students of history.

Scores of striving dictatorial groups within our country, plus striving ideologies within our country, may bring the over-all dictator, and what will he do? Will he be Marcus Aurelius or Adolph Hitler? Will he build an earthly heaven? Will he put us through the gas chamber, or starve us, or merely enslave us? Will he build or will he wreck? Power corrupts and absolute power corrupts absolutely, so we know what the dictators will do in the long run, not a very long run either.

The major problem facing the generation that reads this book is not the control of natural resources. It is the control of the human spirit residing in men with science in their heads. What have they in their hands? Bombs? or benefits to share? It is one of our great misfortunes that the sentence, "It is more blessed to give than to receive," has never yet been a motto on the wall of any foreign office, or, so far as known, of any American business corporation. Is not the real need a careful re-appraisal of our spiritual resources and their importance?

In times past we did say, "The wicked will go to Hell." Now we have to admit that the wicked may get bombs and send us— Our material possessions are as nothing; moral values are suddenly become the overpowering reality. John Haynes Holmes puts it thus: "We know too much, we care too little."

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(Reference numerals to all graphs, maps and photographs are italicized.)